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FARMERS' BULLETINS
Nos. 1651-1675

WITH CONTENTS

PREPARED IN THE INDEXING SECTION

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1933

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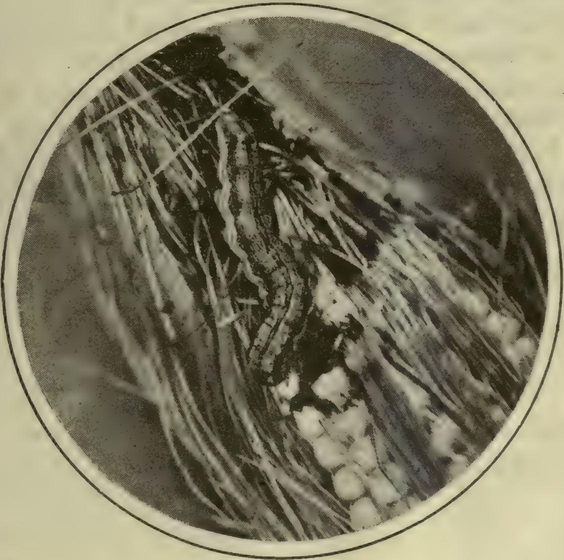
U. S. DEPARTMENT OF
AGRICULTURE
FARMERS' BULLETIN No. 1651

THE CORN EARWORM
AS AN ENEMY OF FIELD CORN
IN THE
EASTERN STATES



EVERY CORN GROWER is familiar with the corn earworm, but few realize the full extent of the loss it occasions to the field-corn crop of this country. Conservatively estimated, this loss amounts annually to $40,000,000.

Each grower of corn, with little extra cost or effort, may reduce his loss from earworm ravages by at least one-half if he will select a variety of corn well suited to his local conditions, but having a long, tight husk, and will plant this variety, within the limitations of good yield requirements, so as to have it silk at the most favorable time—that is, when the moths of the earworm are least abundant.

This bulletin describes the different stages of the insect, and shows how it damages corn, how it is partly kept in check by its own habits and its natural enemies, and how a knowledge of its life history will aid the corn grower in protecting his crop.

This bulletin is a revision of and supersedes Farmers' Bulletin No. 1310, The Corn Earworm: Its Ravages on Field Corn and Suggestions for Control.

Washington, D. C. **Issued January, 1931**

THE CORN EARWORM[1] AS AN ENEMY OF FIELD CORN IN THE EASTERN STATES

By W. J. PHILLIPS, *Senior Entomologist*, and GEORGE W. BARBER, *Associate Entomologist, Division of Cereal and Forage Insects, Bureau of Entomology*

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IMPORTANCE AS A CORN INSECT

THE CORN EARWORM is the most destructive insect enemy of ear corn in the United States and it occurs throughout this country wherever corn is grown. It is most destructive in the Southern States, where the breeding season is longer and where its most important secondary host plant, cotton, is grown in abundance. Sweet corn is especially attractive to the earworm. Even in the North the losses are heavy, while in the South the production of sweet corn is rendered almost impossible by this insect. Although field corn is not so severely injured, nevertheless it has been estimated that 2 per cent of this crop is destroyed annually by the earworm. Even at the low farm valuation of the 1929 crop of corn ($2,048,134,000)[2] this means a loss, for this crop alone, of over $40,000,000. In other words, the American farmer grows, on an average, approximately 2,000,000 acres of corn each year to feed the earworm.

OTHER FOOD PLANTS

Although corn is its favorite food, this pest is also an important enemy of several other crops. On cotton it ranks, in amount of damage done, next to the boll weevil. When feeding on cotton it is called the "bollworm." Under the name of "tomato fruitworm" it is known as a very destructive enemy of early tomatoes in the

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[1] *Heliothis obsoleta* Fab., order Lepidoptera, family Noctuidae.
[2] United States Department of Agriculture Yearbook, 1930, p. 626.

Southern States. The late broods attack the buds and seed pods of tobacco and feed also within the pods of string beans. The larvae prefer to feed upon the grain or fruits of its various host plants, but when these are not available the leaves are devoured, especially where the insect is very abundant. On vetch, for example, the earworm assumes migratory habits similar to those of the armyworm. Alfalfa is sometimes attacked, especially in the irrigated sections of the Southwest.

In addition to being a major pest of the crops mentioned above, the earworm larvae can subsist on a great variety of other plants, some of which are cowpea, okra, sunflower, beggarweed, crab grass, castor bean, squash, and green peppers, to mention only a few of the more important ones.

This great variety of food plants, as well as its manner of feeding, renders the control of the corn earworm difficult. It should be remembered, however, that where corn in the milk stage is available this is attacked in preference to any other food.

HOW CORN IS DAMAGED

In spite of the large aggregate losses due to the work of the earworm in corn, growers generally have become tolerant of the pest. This is largely due to the fact that they have been familiar with its depredations for many years and do not realize the extent of the losses caused by it.

The damage is caused entirely by the worms or larvae of the insect. In the early plantings the worms attack the "buds" or central shoots, feeding on the tender unfolding leaves. (Fig. 1.) When these injured leaves unfold they present a ragged and unsightly appearance, and such damage is often termed "ragworm" or "budworm" injury. Most frequently such damage results only in slightly reduced yields, although occasionally the plants are badly stunted and produce little grain.

When tassels appear the worms immediately attack them (fig. 1), but this feeding rarely results in serious injury.

Although the moths will deposit eggs on practically any part of the plant, they prefer the fresh silks, and as soon as these appear the majority of the eggs are laid on them. (Fig. 12.)

When the silks and ears appear, the larvae desert all other parts of the plant and turn their attention to them. Earworm larvae feed upon the silks as long as these are fresh, although such feeding is done, except in rare instances, within the protection of the shuck. Newly hatched larvae crawl to the tip of the shuck, push their way in between the silk strands, and start to feed. Corn silk is an attractive food for the larvae only while it is fresh; after it dries out the larvae feed upon the developing kernels. The worms may become full grown upon silk alone in case the shuck is long and fits tightly about the silk. Where the shucks are short and fit loosely about the ear the worms start feeding at once upon the exposed kernels. Partly matured worms, coming to the silks from the tassels, may sometimes sever the silks (fig. 2) before fertilization is complete, thus causing nubbins and poorly filled tips. It is not known to what extent this occurs.

The principal injury occurs when the worms reach the ears, where many of the kernels are destroyed (figs. 3 and 9) while still soft. As the kernels harden the larvae burrow under them, feeding on the germ parts (figs. 3 and 4), which remain soft for a longer period. This type of injury is also important, as such kernels drop out during shucking and handling (fig. 5) and become a total loss.

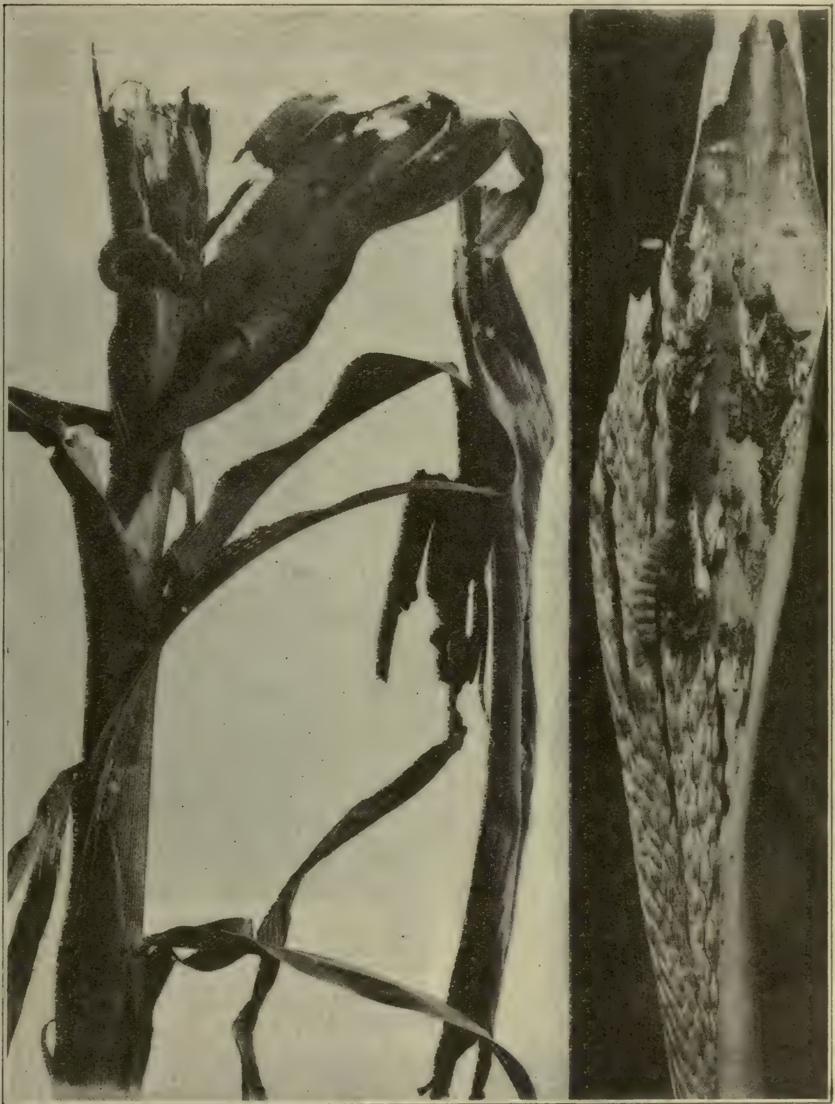

FIGURE 1.—Corn earworm injury to bud (at left) and tassel (at right) of corn Reduced nearly one-half. (Quaintance and Brues)

Careful observations in Virginia have shown that the actual feeding of earworms on the kernels causes from 1 to 17 per cent reduction in the weight of shelled corn. The writers have observed some fields, grown under exceptionally unfavorable conditions, where the loss due to earworms would easily reach 50 per cent.

INJURY TO GRAIN BY OTHER ORGANISMS FOLLOWING EARWORM FEEDING

The indirect injury to the ears which results from the work of the earworm is sometimes as important as the direct loss. Molds, which would not otherwise gain entrance to the ears, are carried in by the worms, or enter with rain through holes in the husk (fig. 6) bored by earworms or at the tip where silks severed by the worms have fallen out (fig. 2). Within the ear, molds breed upon the mass of excrement (fig. 3) and damaged kernels (fig. 7) left by the worms, and often destroy the remaining uninjured kernels. Ears severely injured by molds are unsafe to use for feed, especially for horses. Other insects, such as the grain beetles and weevils, which are unable to penetrate sound, long, tight husks, often gain admission to the ears through husks (fig. 6) or silks (fig. 2) injured by earworms. In the far South the work of these pests is very important. This

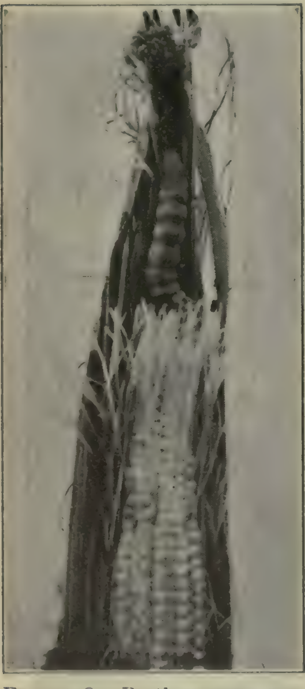

FIGURE 2.—Partly grown earworm severing fresh silks before fertilization of the ear is complete. Slightly reduced. (Photo by R. C. Smith)

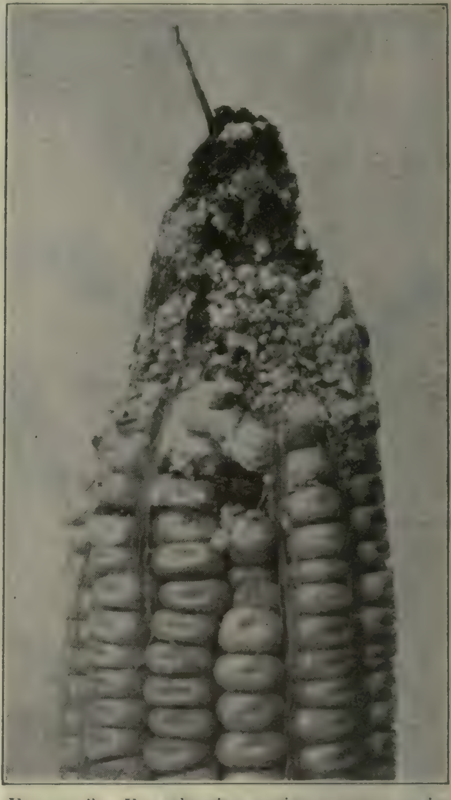

FIGURE 3.—Ear showing serious earworm injury. Note abundant excrement where a large number of kernels have been entirely destroyed while soft; also partly visible earworm still feeding in the germ part of the hardened kernels. Slightly enlarged. (Photo by R. C. Smith)

kind of damage would be greatly reduced if all ears had long, tight husks, which largely prevent the entrance of earworms.

It is impossible accurately to estimate the loss which in these ways is indirectly due to the earworm feeding. It is probably at least half as great as that caused by direct injury.

OTHER INSECTS CAUSING SIMILAR INJURY TO CORN

Several other insects cause injury to the buds of young corn similar to that caused by the earworm. Among these are the larger corn stalk borer (*Diatraea zeacolella* Dyar), the southern corn rootworm (*Diabrotica duodecimpunctata* Oliv.), the common stalk borer (*Papaipema nebris* Guen., form *nitela* Guen.), and the fall army worm (*Laphygma frugiperda* S. and A.).

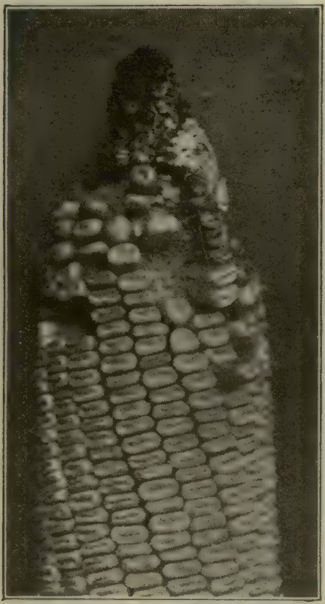

FIGURE 4.—Injured ear typical of results of germ feeding by earworm. Note missing kernels. About five-eighths natural size. (Photo by R. C. Smith)

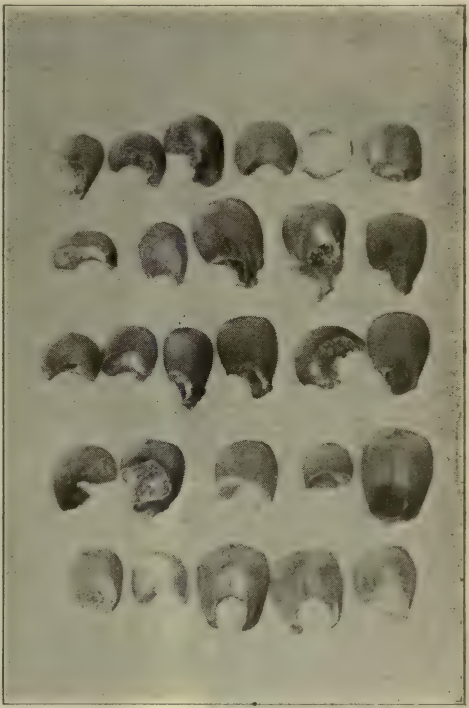

FIGURE 5.—Hardened kernels with germ portions destroyed by earworms. Such kernels drop from ears during handling and represent serious loss. Natural size. (Photo by R. C. Smith)

The ears of late corn also are frequently attacked by larvae of the fall army worm, and an occasional cutworm makes its way to the ear. The corn earworm can be distinguished from these other larvae, however, by the presence of the characteristic and conspicuous stripes that run the full length of the body.

The European corn borer (*Pyrausta nubilalis* Hbn.) frequently feeds in the ears of corn, causing injury similar to that of the earworm. The larvae of this insect are cream colored and about an inch long when full grown. They feed throughout the plant, in the tassel, stalk, shuck, ear, and cob. Feeding often starts in the tassel, the larvae burrowing downward in the stalk. The tassel thus weakened often breaks over, a character frequently used in detecting the presence of this insect in cornfields. The corn borers pass the winter as larvae in the cornstalks, where they pupate and give rise to moths the following May and June, whereas the corn earworms pass the winter as pupae, several inches below the surface of the soil.

THE STAGES OF THE EARWORM

During its lifetime the corn earworm passes through four distinct stages—the egg (fig. 8), the larva or worm (fig. 9), the pupa (fig. 10), and the moth or adult (fig. 11). Few growers, however, are familiar with it except when, as a partly grown worm, it is feeding voraciously in the ear.

If the leaves are carefully examined in the spring a few eggs may be found. Later, when the silks are beginning to appear, the eggs are more easily detected because large numbers are often laid on the silks of a single ear. (Fig. 12.)

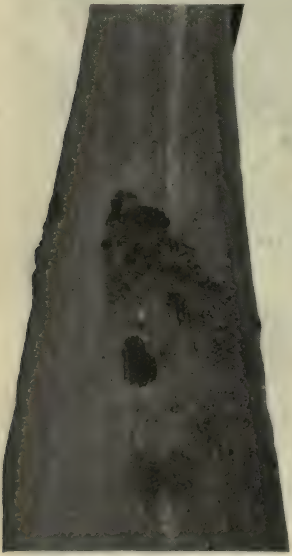

FIGURE 6.—Hole through husks made by earworm. Such openings afford entrance to rain, molds, and weevils. About natural size. (Photo by R. C. Smith)

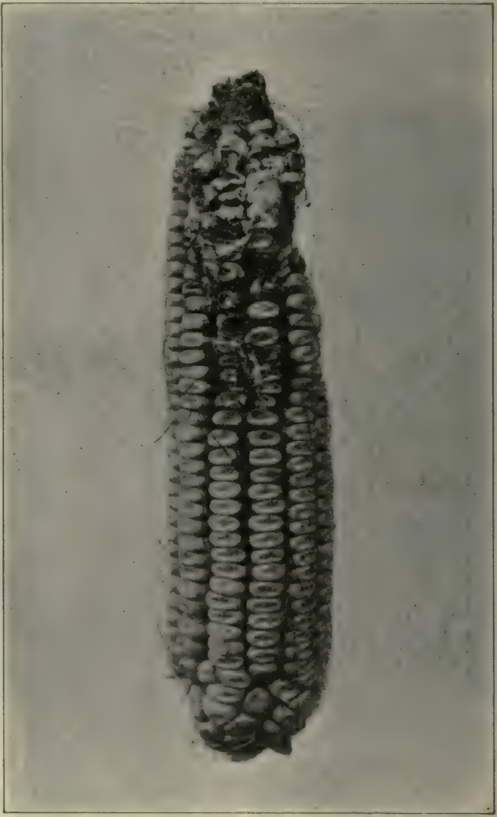

FIGURE 7.—Severe earworm damage followed by mold injury. About one-half natural size. (Photo by R. C. Smith)

THE EGG

The egg (fig. 8) is about half the size of the head of a common pin. It is shaped like a ball flattened at opposite ends. When first laid it is light yellow, but appears white against the dark green of the corn plants. It soon darkens and when ready to hatch has become a dusky brown. Hatching occurs from two to eight days after the egg is deposited, the length of time depending on the temperature.

THE LARVA OR EARWORM

The newly hatched larva is whitish, with a black head, and is very small. Growth is very rapid. The worm attains full size in from 13 to 28 days after hatching. The increase in size is accomplished by the process known as molting. Every two to five days the old hard skin is split down the back and cast off, after which the worm expands greatly in size before the new skin has become hardened. Five such molts usually occur during the process of growth. Each molt is preceded by an inactive period of some hours, during which the larva is helpless. When full grown (fig. 9), the earworm is about 1½ inches long and very robust. The coloration at this time varies greatly, many of the larvae being beautifully marked with conspicuous stripes. A few are without stripes and may be pink, green, cream, or yellow; the majority are marked with prominent stripes of varying shades of cream, yellow, brown, slate, and black. Although, as stated, some larvae are in one-color tone, the majority have stripes and dots of two or three colors. The larval stage is the only destructive stage of the insect. When one has become acquainted with the habits, arrangement of the stripes, and general robust appearance of the earworm, it is not easily confused with any other insect found on corn. The best way to become familiar with the larva is to open several ears of infested corn in midsummer and examine the larger worms. (Fig. 9.)

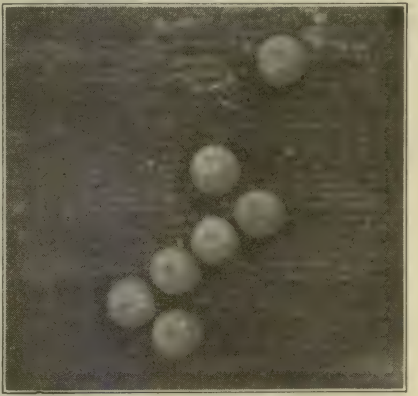

FIGURE 8.—Eggs of earworm on corn leaf. About eight times natural size. (Photo by R. C. Smith)

THE PUPA OR RESTING STAGE

When full grown the larva leaves the ear, usually by boring out through the husks (fig. 6), and drops to the ground. It enters the soil as soon as possible, and bores down to a depth of from 1 to 9 inches, varying with the hardness of the soil, moisture, and weather conditions. The larva then forms a cell. (Fig. 13.) In order that the moth may easily reach the surface, a smooth open passageway is constructed from the cell to within about one-half inch of the surface; then the larva returns to the cell, where it transforms into a pupa. (Figs. 10 and 13.) During this resting stage the great changes take place by which the worm becomes the moth. The pupa is light brown. about three-fourths of an inch long, and rather stout. It is very delicate and helpless. Many pupae are destroyed by moles and other enemies, and by the disturbance of the cells in the process

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of plowing or harrowing. When the changes are complete the moth emerges from the pupa and makes its way to the surface, where the wings expand and harden. In midsummer the period from the time the larva leaves the ear until the moth emerges may be as short as 14 days. It is usually somewhat longer, and it may be several months, as the insect passes the winter in the pupal stage.

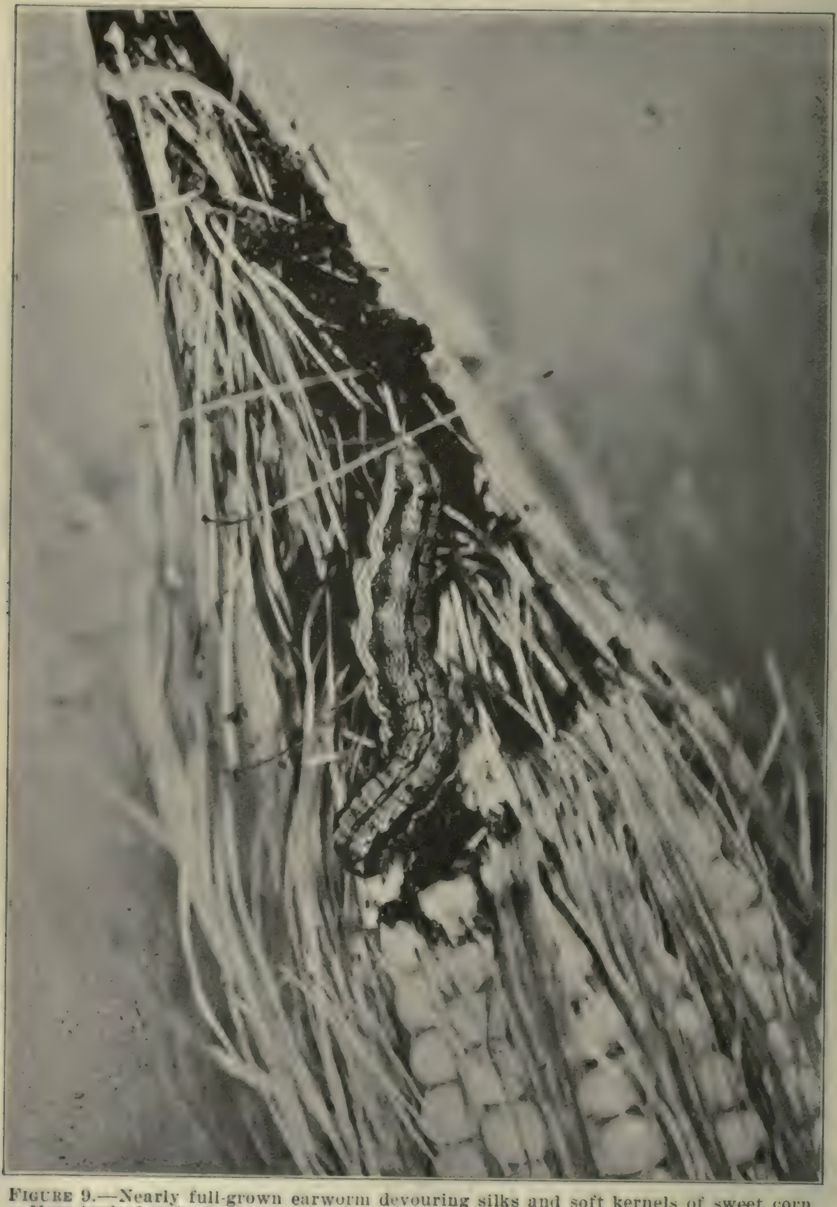

FIGURE 9.—Nearly full-grown earworm devouring silks and soft kernels of sweet corn. Note typical striped appearance of the larva. About one and one-half times natural size. (Photo by R. C. Smith)

THE MOTH OR ADULT

The moth (fig. 11) is about three-fourths of an inch long and has a wing expanse of 1½ inches. The coloration is dull and the shades vary from a light olive green to a rather dark reddish brown. Although it is not strongly attracted to lights, it is similar to those moths which are common about lights in the summer. The moth makes itself so inconspicuous that the grower may seldom see one, unless it is noticed at midday resting in the central shoot or bud of a corn plant. The moths become active in the early evening, feed on the nectar of various flowers, and then fly in search of suitable plants on which to lay their eggs.

Soon after emergence, mating takes place and egg laying begins. Each female deposits many eggs in an evening, distributed over a number of plants taken at random. The eggs are laid singly, but many may be laid on parts of one plant before another is visited. The females live about 12 days, and during this time each may deposit between 400 and 3,000 eggs, the average being about 1,000. The moths are extremely active, strong and rapid fliers and may fly long distances in search of suitable plants on which to lay their eggs.

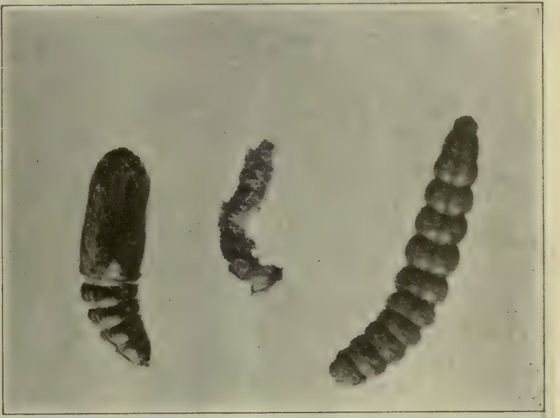

FIGURE 10.—The corn earworm. At right, larva after entering ground and ready to pupate; in center, cast skin; at left, pupa. About one and one-fourth times natural size. (Photo by R. C. Smith)

SEASONAL HISTORY

Within certain limits, the lengths of the egg, larval, and pupal stages of the corn earworm vary with the temperature, being shorter in hot weather and longer in cooler weather. If each stage were passed in the shortest time as given above, the entire life cycle could be completed in a month. In other words, under the most favorable conditions it requires only 30 days from the time an egg is laid until the adult insect appears. In the southern part of the United States this rapid development does occur in midsummer, and there may be as many as seven generations of the earworm annually. In the extreme northern part of the country, however, there is only a single generation each year. Between these extremes the number of generations varies with the latitude, altitude, and other factors which influence seasonal temperatures. Throughout the greater part of the Corn Belt there are three or four generations annually. The number of generations largely determines the destructiveness of this pest in any given area.

In Virginia the moths begin to emerge from the overwintering pupae during the last part of May or the first week in June and continue emerging until the last week of July. Their eggs, which begin the first generation of the year, are most abundant during the last of June and the first two weeks of July. In the last part of July or the first part of August, depending on the season, there is usually a period during which few or no eggs can be found by the most careful observation. Moths of the first generation soon appear, and eggs are deposited in greater abundance than before. These eggs begin the second generation. From this time until frost eggs can always be found, the broods overlapping, though the eggs are more abundant at some periods than at others. The earliest moths of the second generation appear during the last part of August and lay the eggs that begin the third generation. In Virginia it is this generation which passes the winter in the pupal stage.

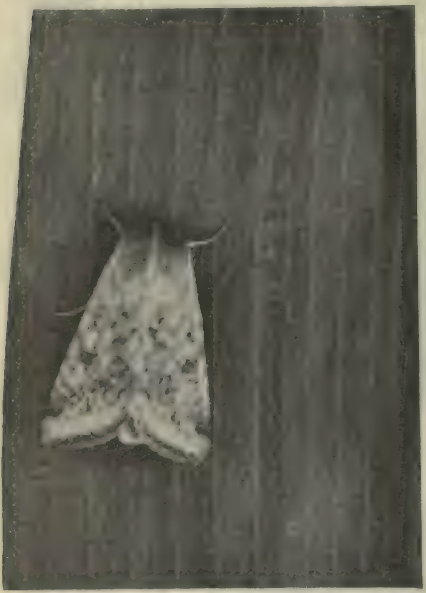
FIGURE 11.—The adult or moth of the earworm resting on corn leaf. About one and one-fourth times natural size. (Photo by R. C. Smith)

Farther south the moths appear earlier in the spring, attacking corn, vetch, and tomatoes. The later generations develop on late corn, cotton, and tobacco.

NATURAL LIMITING FACTORS

CANNIBALISM

The most important factor tending to reduce earworm ravages on corn is the earworm's habit of cannibalism. Wherever two worms come into chance contact with each other they fight until one or both are injured beyond recovery. If one survives, it will often partly or entirely consume its foe. Since by far the greater number of the newly hatched worms enter the ears through the silks, contact is very frequent and only a few worms survive to reach the kernels. Scores of larvae sometimes enter ears, but few survive because of this cannibalistic habit. This is especially true where husks are long and tight (fig. 17), because, in this case, the silk channel is long and narrow, and the chances for more than one survivor are greatly lessened. When husks are short or loose (fig. 16), worms easily find their way to various parts of the ear without feeding much on the silk or disturbing one another. When thus widely separated they feed unmolested and many more reach maturity. Comparatively few worms enter the ear by boring through the husk.

PARASITES AND PREDACIOUS ENEMIES

A tiny wasplike insect (*Trichogramma minutum* Riley) is the most important egg parasite. (Fig. 14.) Although it is usually present in the cornfields, it varies greatly in abundance. Occasionally in some seasons fully 90 per cent of the eggs fail to hatch because of the work of this insect. This little parasite also attacks the eggs of many other injurious insects.

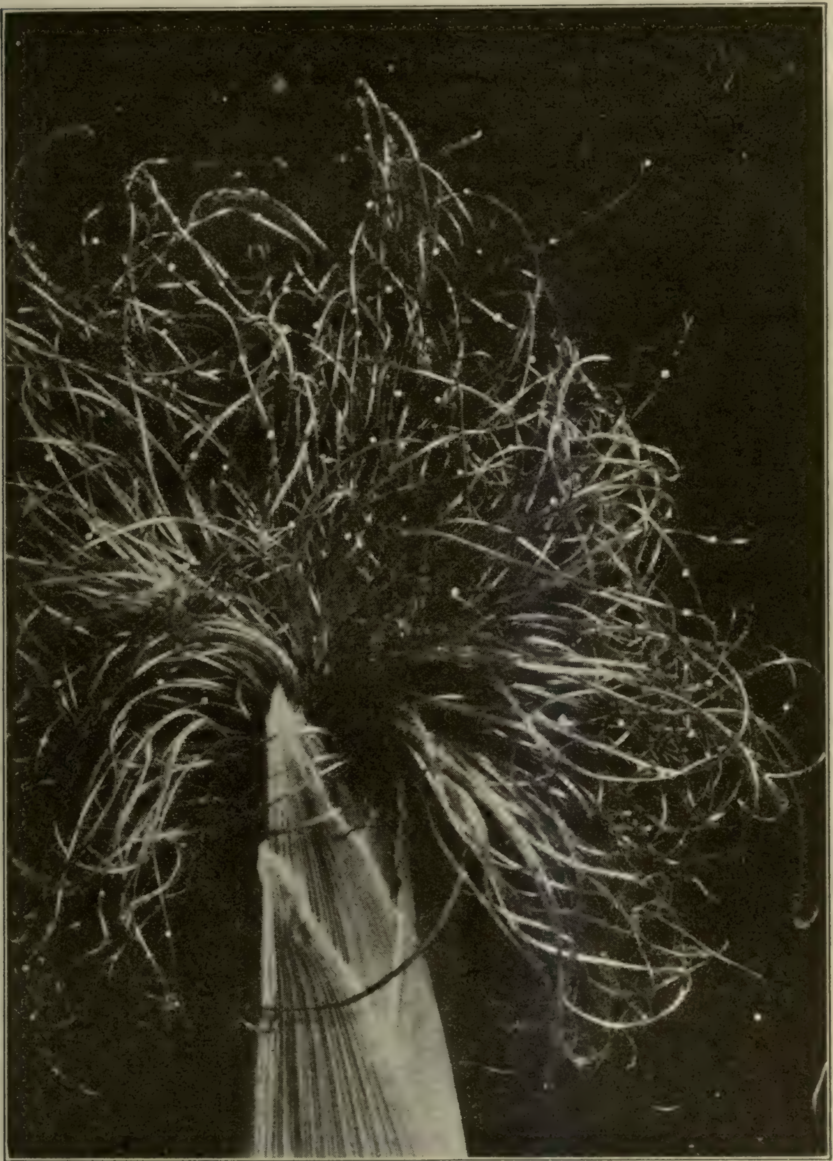

FIGURE 12.—Ear in full silk, at the stage when it is most attractive to the earworm adults for egg laying. Note the large number of eggs scattered through the silks. Slightly enlarged. (Quaintance and Brues)

Earworms feeding upon the ears of corn are usually fairly well protected and parasitism under this condition is therefore rare and unimportant. When the larvae feed upon such plants as vetch

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and alfalfa they are easy prey to several parasites, particularly a two-winged fly (*Winthemia quadripustulata* Fab.).

The pupa is formed within the soil and therefore is practically secure against parasitism.

The most important predatory insect enemy of the earworm egg and small larva is a small blackish bug (*Triphleps insidiosus* Say) (fig. 15) about one-sixteenth of an inch in length. Although this bug occurs upon many species of plants, it is perhaps most abundant upon corn, on which it prefers to breed. These bugs are especially abundant on corn silks, in which they deposit their eggs and upon which the reddish nymphs feed. These little bugs are very active and destroy great numbers of earworm eggs and young larvae by puncturing them with their beaks and sucking out the contents. Sometimes as many as 25 of these bugs may be found on a single corn plant.

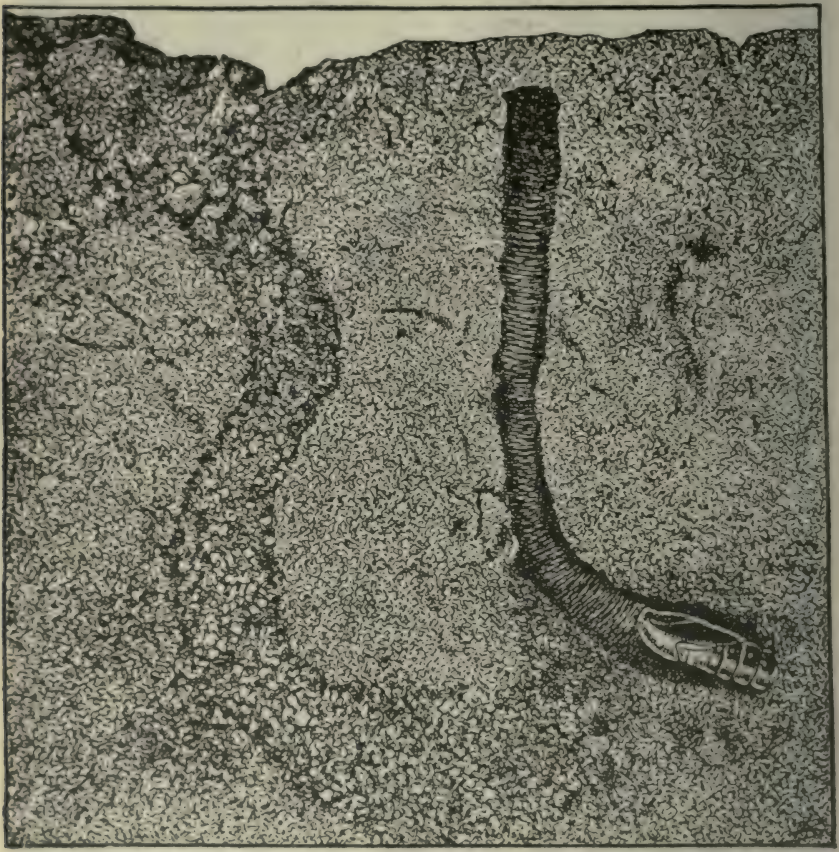

FIGURE 13.—Pupa of the earworm in its burrow in the soil. Note the disturbed soil where the larva worked its way down and the smooth channel constructed for the escape of the moth. About one and one-fourth times natural size. (Drawn from Quaintance and Brues)

The Bureau of Biological Survey states that 21 species of birds are known to feed on the corn earworm. Most important are the

Brewer's and California red-winged blackbirds, the boat-tailed grackle, English sparrow, and downy woodpecker. As many as 10 larvae of the earworm have been found in a single stomach of the cardinal and more than 50 in that of the boat-tailed grackle.

Moles are undoubtedly the most important enemy of the earworm pupae. Late in the season cornfields may be noticed in which mole tunnels branch out in all directions. Moles undoubtedly destroy large numbers of the pupae of the earworm in such fields. Their taste for this food is so keen and they are so clever in locating the pupae in the soil that it taxes the entomologist's ingenuity to devise mole-proof cages for the earworm pupae used for experimental purposes.

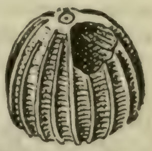

FIGURE 14.—Earworm egg parasitized by *Trichogramma minutum*. About twenty-four times natural size. (Quaintance and Brues)

WEATHER CONDITIONS

Variable weather conditions have an important effect upon the earworm throughout its seasonal history. Summer storms are among the most important of weather factors in limiting the abundance of the insect. Wind and rain dislodge many eggs which fall to the ground and are destroyed. The first frosts and freezes in the fall kill all larvae that are not well protected from the cold. Large numbers of hibernating pupae die in the soil from cold, excess moisture, and other unfavorable conditions. In central Virginia not over 5 or 6 per cent of the larvae which enter the soil in the fall survive to emerge as moths the following spring.

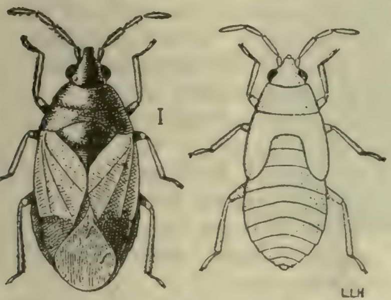

FIGURE 15.—Adult and nymph of *Triphleps insidiosus*. This bug destroys large numbers of eggs and young larvae of the earworm. About fifteen times natural size. (Quaintance and Brues)

DISEASE

During prolonged periods of wet weather large numbers of larvae die within the ears of corn as a result of certain diseases. Many more die from similar causes after they enter the soil to pupate. Many pupae die of disease in the hibernation burrows. The young larvae rarely seem to suffer in this manner. As a whole, disease is an important factor in limiting the earworm.

IMPORTANCE OF NATURAL AGENCIES

Considered collectively, all the natural limiting factors profoundly affect the abundance of the earworm and account for the fact that rarely more than two to five larvae survive to maturity upon a single ear of corn.

Were it not for the important aid rendered by these agencies the injury to the crop would be many times greater and would probably make corn growing very difficult if not well-nigh impossible. Unfortunately, these natural agencies do not effect a sufficient degree of control to render artificial measures unnecessary.

METHODS OF LIMITING DAMAGE TO FIELD CORN

The earworm is of such general occurrence and has been known as a pest for so long that the farmer, especially in the Southern and Central States, has come to look upon its presence as an inevitable consequence of corn planting. Expensive methods of control are not warranted because of the small margin of profit and the relatively low commercial value of the crop. Furthermore, it is grown over such large areas that individual treatment of each plant is impracticable. As a rule, therefore, little has been done by the grower to combat the pest.

A careful study of the problem for a period of years has shown that the major part of the earworm depredations may be prevented if the farmer will act in accordance with the following simple suggestions. The practices recommended, for the most part, add very little to the labor and expense ordinarily required in growing the crop.

TIME OF PLANTING

The most favorable time to plant field corn in order to limit earworm injury is as early in the season as is consistent with favorable conditions for germination and growth. A long series of studies made in central Virginia has shown that, on an average, field corn planted in that district the last week in April was damaged the least, and those plantings made during the last week in May and the first two weeks of June were most severely injured by the earworm. Corn planted between these dates was injured to an intermediate degree. Late-planted fields have been observed in central Virginia in which fully 50 per cent of the kernels were destroyed by the earworm. Late plantings are not only more severely damaged, but great numbers of larvae enter the soil to hibernate, and thus serve to stock the soil with the insect for the following year. On the other hand, moths that emerge in early-planted fields fly elsewhere in search of food and suitable places for oviposition, since such corn is no longer very attractive to them; therefore, very few individuals enter hibernation under these conditions, thus reducing the infestation for the succeeding year.

It is also very important to plant all of the field corn for the locality or community within as short a period as possible in order that all the plants may come into silk at approximately the same time. A short planting period gives a relatively short period during which the season's planting of corn is susceptible to attack by the earworm. In addition, this tends to distribute the earworm injury throughout the entire crop, so that it is not unduly concentrated on any one field. Likewise, missing hills should not be replanted, as plants from such hills silk much later and attract moths to the field for oviposition, thus greatly increasing earworm injury.

Where the larger corn stalk borer occurs in destructive numbers its presence should be taken into consideration in determining the planting date. In eastern Virginia this insect frequently does serious damage to corn planted before the first week in May. Therefore, corn should be planted as early as is consistent with escape of serious injury by the stalk borer, which, in Virginia, is about the first week in May.

The planting periods suggested here apply particularly in central Virginia, where the insect has been most intensively studied. They apply to long-season varieties; the short-season varieties should be planted about 10 days later to escape serious damage by the earworm.

CHARACTER OF HUSK

The character of the enveloping husk is a very important factor influencing earworm injury to corn. The most desirable husk should extend from 2 to 6 inches beyond the tip of the ear, and above all it should close tightly around the silks. The writers have found that ears so protected suffer only half the loss in weight shown by ears of the same variety grown under identical conditions and with the same percentage of infestation but having loose husks. The most undesirable husk type is one that is loose about the grain and is so short that the tip of the ear is exposed. This has held true for nine varieties having different husk characters. Where husks are tight, ears with very long husks are less damaged by the earworm than ears having only moderately long husks. Moreover, very long, tight husks have been found to be of great assistance in reducing weevil injury to corn. Bird injury to corn in the field is much less in ears with long tight husks than in those having short or loose ones. (Fig. 16.) Where these types of injury are important, the grower should select for seed ears having husks which are not only tight but also quite long. (Fig. 17.) By such wise selection the corn grower can obtain these desirable husk characters in the variety which he has found best suited to his needs and greatly reduce the losses from these various causes.

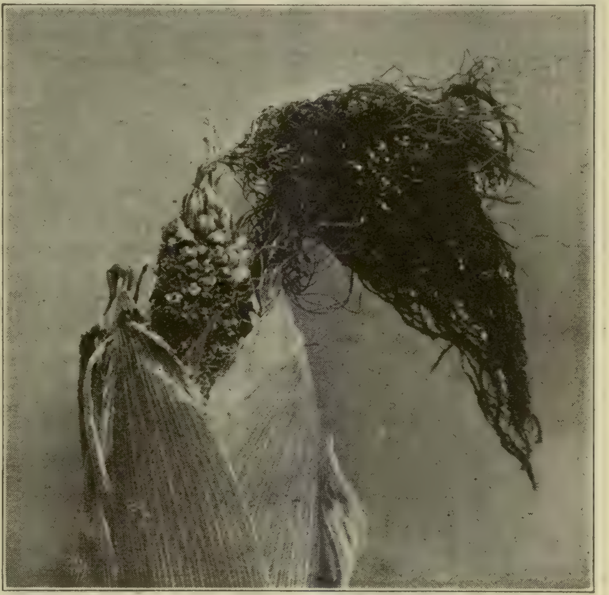

FIGURE 16.—Undesirable husk characters. Note bird injury to exposed tip. Ears having husks of this type are especially susceptible to earworm injury. (Photo by R. C. Smith)

SOIL PRODUCTIVENESS

To plant corn on poor land is to invite severe earworm injury. This is because of the long, irregular silking period and the high percentage of poor ears produced on such soil. Fertilization, crop rotation, the use of legumes, and other measures which increase the productiveness of the land and make for a better crop of corn, aid in reducing the severity of earworm injury.

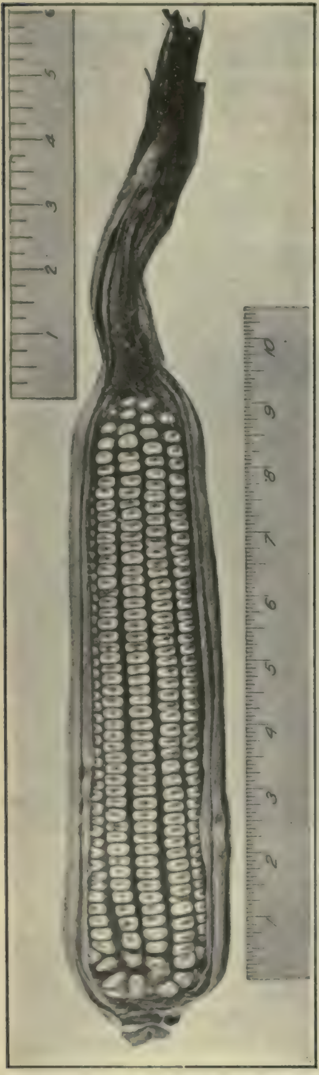

FIGURE 17.—Desirable husk characters. Shuck protection like this will greatly reduce both earworm and weevil injury. (Kyle)

PLOWING

Plowing of cornland at some period during the fall, winter, or spring has been recommended as a control for earworms for many years. It will be recalled that the larva burrows into the soil in the fall to a depth of from 1 to 9 inches and then constructs a tunnel or burrow extending upwards to within a half inch of the surface of the soil. The moth is rather delicate, and if such a tunnel were not provided it could not reach the surface of the soil to fulfill its function of egg laying. The advantage of plowing is to destroy the hibernating pupae, or to disturb their emergence burrows so as to make the emergence of moths impossible. In the operation of plowing, many pupae are crushed, others have their emergence burrows obliterated and the moths are thus unable to reach the surface. In heavy soils plowing may be done at any time during the fall, winter, or spring, but in light, friable, or sandy soils plowing seems to be most desirable during the fall or winter. Soils subject to erosion through the winter should not be plowed in the fall. Undoubtedly marked beneficial results could be obtained if the farmers of an entire community would plow, during the fall or winter, all fields and fence rows that had produced corn, or other crops, or weeds, upon which the late broods of earworms had developed.

DEGREE OF CONTROL POSSIBLE

A question which naturally will arise in the grower's mind is, To what degree can this insect be controlled by the use of methods suggested in this bulletin? The writers have found that a very marked control is possible. In 1921, a year of very heavy infestation, the ears which had long, tight husks, which silked at the most favorable time, and were of a variety well suited to local conditions, had less than one-half of 1 per cent of corn eaten by earworms. On the other hand, a variety which had a short, loose husk, and which was planted at an unfavorable time, showed 17 per cent loss. This difference shows the degree of control effected by changes in cultural practice alone, and without community cooperation. Effort by an entire community would doubtless effect much better results.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1652

DISEASES AND PARASITES *of* POULTRY

CHICKENS, turkeys, ducks, geese, and pigeons are susceptible to many diseases, some of which are highly infectious. Disease germs pass rapidly from bird to bird of the flock, and may be carried by one means or another to neighboring flocks, producing extensive outbreaks, or epizootics.

Poultry are also infested by numerous kinds of parasites, some of which live on the surface of the body and others internally, especially in the crop, stomach, and intestines. These parasites may seriously affect the health of the birds by preventing their nourishment and by causing irritation and inflammation of the parts which they attack.

Certain diseases respond favorably to treatment. Others resist all efforts at treatment and cause heavy losses.

Preventive measures properly applied offer the surest means of controlling diseases of domesticated birds.

The purpose of this bulletin is to inform the poultry owner as to the characteristics of the various diseases and infestations in order that he may intelligently use the most approved methods of combating them. However, it is in no sense intended to replace the valuable services and advice of the trained veterinarian, which, if available, should by all means be obtained.

This bulletin is a revision of and supersedes Farmers' Bulletin 1337, Diseases of Poultry.

Washington, D. C.

Issued January 1931
Revised April 1936

DISEASES AND PARASITES OF POULTRY

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DOMESTIC BIRDS are subject to a considerable number of diseases, some of which spread rapidly through the flock and cause high mortality. They may also be infested by various kinds of parasites, some of which live on the surface of the body and others in various passages or organs within the body. These parasites are injurious because they take part of the nourishment which should be used by the bird to put on flesh or to produce eggs, and also because by their movements and other activity they cause irritation and inflammation of the parts they attack.

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[1] Deceased.

[2] Revised by Hubert Bunyea, Walter J. Hall, and Eloise B. Cram. F. C. Bishopp, Bureau of Entomology and Plant Quarantine, assisted with the part relating to insects, mites, and ticks.

The contagious diseases which are caused by germs and viruses and the weakness and loss of flesh caused by the larger parasites just mentioned are the most important conditions which the poultryman has to consider in the endeavor to keep his birds healthy. These germs, viruses, and parasites should be kept out of the flock by suitable preventive measures, because disease may be avoided much more easily and cheaply than it can be cured. The aim in studying the diseases of poultry is, therefore, to learn how to prevent the diseases as well as how to control them once they become established.

DISEASE PREVENTION

To prevent diseases, we need to understand something about them. Some diseases are caused by infection; others result from faults of nutrition; and still others are traceable to the general conditions surrounding the flock.[3]

The first rule of health is sanitation. The observance of this rule comprises the following points: (1) Quarantining of new stock until it is known to be healthy; (2) protecting the flock from access to polluted drinking water, spoiled or infected feeds, or contaminated grounds; (3) burying, burning, or otherwise making proper disposal of diseased carcasses; (4) thoroughly cleaning and disinfecting premises contaminated by disease; (5) protecting the flock from vermin and diseases and parasites carried by free-flying birds; and (6) preventing persons who have unhealthy chickens from entering the poultry yards or houses.

Proper nutrition is the second rule of health. Some diseases are caused by a ration lacking certain elements, while others are due to excessive feeding of some feeds. Rickets, nutritional roup, and polyneuritis are deficiency diseases, whereas obesity and gout are attributed to excesses of unbalanced nutrition. A balanced cereal ration with meat scrap and shell or bone, a regular allowance of green feeds, and clean water, should contain all the vital elements of nutrition required by birds.

The third rule of health is good surroundings; that is, roomy, comfortable, well-ventilated poultry houses, free from drafts or dampness, and with ample provision for exercise, and suitable exposure to the direct rays of the sun.

Large flocks should be divided into smaller units for convenience in care and feeding and as an aid to disease prevention. Birds of various ages and of different species should, if possible, be kept separate.

DISEASE CONTROL AND ERADICATION

The extensive use, in recent years, of artificial and wholesale methods of incubation, housing, and feeding has increased the opportunity for disease development and transmission at an alarming rate so that disease has become one of the greatest barriers to success with poultry. New and baffling diseases are springing up, and their diagnosis and control are essential.

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[3] Additional information on the correct feeding and housing of poultry is contained in Farmers' Bulletin 1541, Feeding Chickens, and Farmers' Bulletin 1554, Poultry Houses and Fixtures, which may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., price, 5 cents each.

Normal, healthy chickens do not require drugs of any kind. When an outbreak of disease occurs in a flock the first procedure is to get an accurate diagnosis. This can be done best by the local veterinarian, but if no practicing veterinarian is available, it is a good plan to communicate with the State agricultural experiment station. If the disease proves to be a contagious one, the next step is to remove the sick birds from the flock. Remedies and curative treatments are useless in most of the devastating contagious diseases, and the treatment of sick birds increases the opportunity for the spread of the disease to the rest of the flock. The proper handling of contagious diseases consists in sanitation, preventive treatment, and eradication rather than cure.

Diagnostic tests for pullorum disease and tuberculosis, as well as chicken-pox vaccination, should be conducted by a veterinarian experienced in poultry diseases.

DISINFECTANTS AND THEIR APPLICATION [4]

Good disinfectants destroy the germs of contagious diseases, and in some cases, external parasites such as lice and mites. Since the germicidal power of disinfecting solutions is rapidly spent by contact with organic matter it is always important to give special attention to the cleaning of the premises, the removal of all litter, contaminated soil, and manure, before applying the disinfecting solution. The disinfectants should be thoroughly applied to the interior of the houses, worked into all the cracks and crevices, spread over the ceiling and the floor, the roosts, dropping boards, nest boxes, and feeding and drinking vessels. Merely sprinkling the germicide here and there is of little value. Disinfectants are most easily applied to the walls and ceilings with a spray pump or with a brush. As it is difficult to keep them from coming into contact with the face and hands, the mixtures least harmful to persons should generally be used.

In the case of an actual outbreak of virulent disease it is advisable to use for disinfecting purposes a whitewash made by dissolving 1 pound of commercial lye (containing 94 percent of sodium hydroxide) and 2½ pounds of water-slaked lime in 5½ gallons of water. If the solution is not used at once, it should be tightly covered to prevent deterioration. This solution is cheap, odorless, and destructive to almost all kinds of disease germs. On prolonged contact, however, it may be injurious to painted or varnished surfaces, and to some fabrics. It is corrosive to aluminum, but relatively harmless to the metallic fixtures ordinarily found about chicken houses, and to wooden construction or equipment.

The above-mentioned disinfectant solution has been found through experimentation to be ineffective against the germs of tuberculosis.

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[4] Additional information on the subject is contained in Farmers Bulletin 926, Some Common Disinfectants, and Farmers Bulletin 954, The Disinfection of Stables, which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., price, 5 cents each.

For combating that infection the chicken houses, enclosed runs, and all eating, drinking, and other utensils should be thoroughly cleaned and disinfected with a strong solution of such germicides as carbolic acid or compound solution of cresol. Carbolic acid may be used in 5-percent solution and compound solution of cresol in 3-percent solution.

Kerosene emulsion is frequently used to destroy mites. To make the emulsion, shave half a pound of hard laundry soap into half a gallon of soft water and boil the mixture until all the soap is dissolved; then remove it to a safe distance from the fire and stir into it at once, while still hot, 2 gallons of kerosene. This makes a thick, creamy emulsion or stock mixture. When it is to be used for killing mites in the houses, 1 quart of this emulsion is mixed with 10 quarts of water.

A further means of freeing premises from infection by most germs and parasites is to keep them free of fowls for several months, or a year if possible. Most disease organisms are destroyed if directly exposed to the sun's rays for a short time, and by this means fields and yards are eventually disinfected to a large extent. There are many dark or covered places not reached by the direct rays of the sun, however, and in such spots germs may survive for several months. In the case of highly resistant forms of infection, such as oöcysts of coccidia, disinfection in addition to vacating the premises is a desirable safeguard. It is advisable to place new stock on ground which has not been occupied by poultry for a year or more.

When the runs are heavily contaminated with disease germs, or infested with the eggs of poultry parasites, much added protection can doubtless be given the flock by scaling off the surface of the run to a depth of 4 inches or else liming it and spading or plowing it under to a good depth.

NUTRITIONAL DISEASES

NUTRITIONAL ROUP (VITAMIN A DEFICIENCY)

Nutritional roup is a disease of chickens resembling roup in appearance, but it is due to a deficiency of fat-soluble vitamin A in the ration.

This food element is obtainable from many sources, such as cod-liver oil, butterfat, green feeds, raw carrots, tomatoes, and egg yolks. On being supplied with feeds containing vitamin A in sufficient quantities, fowls affected with nutritional roup usually recover.

POLYNEURITIS (VITAMIN B DEFICIENCY)

Polyneuritis is a nutritional disease affecting birds of any age, although young birds are most susceptible.

The condition is due to a deficiency of water-soluble vitamin B in the ration. This food substance is present in many green feeds and whole grains. A ration restricted to degerminated grain is not suitable for poultry.

The symptoms of polyneuritis are loss of appetite, emaciation, leg weakness, and spasmodic movements of the head or limbs.

Treatment.—Treatment consists simply in the feeding of mixed whole grains and green feeds, together with a mash in which meat or fish meal is included.

GOUT

Gout is caused by the presence of an abnormal quantity of uric acid in the blood, which results in the deposit of urates on the internal organs (visceral gout) or occasionally in the joints (articular gout).

Cause.—Pullets are sometimes placed on a high-protein laying mash too young, or fed protein feeds of poor quality. The increased quantity of uric acid may be induced also by prolonged feeding on substances rich in protein, especially if associated with lack of exercise, or diseases which affect the urinary organs, causing a failure to eliminate the uric acid properly.

Symptoms.—In articular gout the joints of the feet and wings may be involved. At first the joints are swollen and painful. The lesions then form into nodular, tumorlike growths which may later burst, discharging a yellowish, turbid material containing urates. The bird remains sitting as much as possible. The general health becomes affected, and emaciation gradually occurs, with weakness and frequently diarrhea.

Visceral gout is apparent on autopsy only. The internal organs and serous membranes are found covered with chalklike deposits, particularly the heart and the inside of the heart sac. The kidneys and ureters are frequently swollen, pale, and engorged with urates. The course of the disease is slow.

Treatment.—The quantity of meat scrap or other proteins in the ration should be reduced, and the allowance of green feed increased. Some authorities advocate the administration of saline purgatives, such as Karlsbad salt or Epsom salt, which may be followed by the daily administration of tincture of colchicum, two to five drops, to each affected fowl. In the articular form of the disease, the enlarged joints may be opened and the contents washed out. The joint should then be dressed with a protective bandage.

RICKETS (RACHITIS, VITAMIN D DEFICIENCY)

Rachitis (rickets) is a disease of the bones of growing fowls caused by a deficiency of vitamin D in the diet. This deficiency results in failure of the bird to obtain sufficient lime salts from the feed to build strong bones. The bones are soft and deformed, as is frequently shown in chickens with crooked legs or crooked breasts. Catarrh of the intestines sometimes occurs.

To aid in overcoming a tendency to rickets in chicks give 2 percent of fresh cod-liver oil in the mash. Direct sunlight (not through window glass) is also highly efficacious in preventing rickets. Glass substitutes, said to permit the passage of the antirachitic sun rays, may now be obtained on the market. These products are replacing glass on many poultry farms. Growing birds should receive a varied ration, including green feeds, and a supply of ground oystershell or limestone grit and bone.

DEFORMING LEG WEAKNESS (PEROSIS, SLIPPED TENDON, HOCK DISEASE)

Deforming leg weakness is a disease of growing chicks reared in confinement. This disease should not be confused with rickets, as it appears in spite of an adequate supply of calcium and phosphorus and an abundance of vitamin D. Present knowledge indicates that the presence of more than a fraction of 1 percent of inorganic phosphorus in the diet is one of the principal contributing causes but that a deficiency of some vitamin, or vitamin fraction, and an improper calcium-phosphorus ratio are involved.

Symptoms.—The first symptoms noticed are a slight puffiness of the tissues about the tibiotarsal (hock) joint and discoloration due to subcutaneous hemorrhage. This stage is known as enlarged hocks, and if it does not go beyond this stage the bird may recover without permanent deformity. During this stage bending of the distal end of the tibia or the proximal end of the metatarsal bone may occur, which permits the Achilles tendon to slip from the condyles to either the inside or outside of the joint, causing the chick to become knock-kneed or bowlegged. Contraction of the tendon increases the deformity by further bending of the bones and causes permanent flexion of the leg so that the chick is unable to walk at all, and it sits or hops about on the hocks. This results in the bruising of the joint and frequently in the rupture of the synovial sac and joint infection.

Control.—Control consists in prevention rather than treatment as the disease cannot be cured after the resulting deformity has occurred. Avoid the use of bonemeal; high grade limestone or oystershell should be used in place of bonemeal, if additional calcium is required. Likewise, avoid the use of meat scrap and fish meal having a high ash content. The development of the disease may be largely prevented by the feeding of a well-balanced diet in which is included 20 percent of wheat middlings. Rice bran is even more effective than wheat middlings—5 to 10 percent being sufficient—but it is not readily available in all sections of the country. The disease rarely develops when the inorganic phosphorus content of the diet is less than about 0.06 percent. Such a low content of inorganic phosphorus cannot be obtained if meat scrap and fish meal are included in the diet. If these two products are selected for a low ash content, however, the inorganic-phosphorus content of the diet will be relatively low. Diets containing milk as the sole source of animal protein and one or more of the plant-protein supplements are not likely to have a high content of inorganic phosphorus.

OBESITY

Obesity is an abnormal state of fatness and plethora induced by the prolonged heavy feeding of starchy feeds, with insufficient exercise. It sometimes offers mechanical interference to egg laying and tends to cause rupturing of egg yolks or of the liver, leading to death. Obesity may retard other body functions, such as circulation of blood, digestion, and assimilation of feed. The heavier breeds are more susceptible than the lighter breeds.

Treatment.—Feed grain in moderate allowances. Encourage exercise. Temporarily reduce starchy ingredients of mash, and supply green feed or sprouted oats.

"CRAZY CHICK" DISEASE (PROTEIN POISONING)

The condition known as crazy-chick disease occurs in chicks 3 or 4 weeks of age, and is thought to be caused by excessive protein in the ration. This difficulty is especially associated with rapid growth. The principal symptom is muscular incoordination, manifested by the chicks' walking in a circle or falling when attempting to walk. In some instances the chicks are completely helpless. Other chicks show a retraction of the head or trembling of head or limbs. Death may occur within a short time after symptoms appear.

The principal post-mortem changes are observed in the kidneys, which are swollen and congested. On analysis the blood is found to have a high uric acid content.

Treatment.—Change the diet of the chicks for a few days, particularly favoring simple ground-grain mixtures and avoiding the use of proteins, until the disease has been checked. After this the regular feeding methods may be resumed.

INFECTIOUS AND CONTAGIOUS DISEASES

DISEASES CAUSED BY SPECIFIC GERMS

PULLORUM DISEASE (BACILLARY WHITE DIARRHEA)

Pullorum disease (bacillary white diarrhea) is quite widespread, existing in every section of the United States where appreciable numbers of poultry are kept. It causes heavy financial losses, resulting from the deaths of baby chicks, diminished egg production in hens and pullets, reduced hatchability of eggs, and occasionally the deaths of hens due to generalized pullorum infection. Fortunately pullorum disease does not attack other species of domestic fowls to any serious extent.

Cause.—The disease is caused by a toxin-forming germ which is known as *Salmonella pullorum.* Although this germ is quite easily destroyed by direct sunlight, heat, or disinfectants, it has been known to remain alive in soil or manure in sheltered places for many days, or even months. The primary seat of pullorum infection is the ovary of the infected hen.

Mode of dissemination.—The disease is commonly transmitted from the hen to the chick by means of the egg (fig. 1). All eggs laid by an infected or "carrier" hen do not contain the organism, *Salmonella pullorum*, but infected eggs, if hatched, produce infected chicks. Such chicks may die of the disease any time during the first 3 weeks of their lives, or they may survive to maturity and repeat the cycle (fig. 2) by themselves producing eggs and chicks infected with the organism. Chicks having the disease are constantly voiding enormous numbers of the germs in their droppings, thereby spreading the infection. The hatching of infected eggs in an incubator or under a hen may result in the transmission of the disease to other chicks hatched from uninfected eggs in the same incubator or brood. Infected chicks placed in a brooder house with healthy chicks will spread the disease. In the case of the hatchery chicks, however, the danger of acquiring the disease is multiplied by the fact that the eggs for hatching are frequently assembled from a number of flocks, and if one or more of these flocks happen to be harboring the infection, the entire output of the incubator is exposed to the menace of the disease. Many progressive hatcherymen have already realized the importance of taking the initiative in protecting their customers from pullorum disease by requiring the flocks which supply them with eggs to be tested for the presence of pullorum-disease carriers.

Symptoms.—In hens and pullets pullorum disease is limited as a rule to the egg-making organs, and consequently produces no outward symptoms. It may, therefore, exist unsuspected in a flock. In chicks the symptoms of the disease and the deaths which it causes are sometimes wrongly attributed to some other cause, such as fungous pneumonia (aspergillosis), chilling, or overheating. The presence of the disease may be recognized by the following principal characteristics, although a definite diagnosis cannot be made from these alone. In order to diagnose definitely the disease in chicks, clinical observations must be confirmed by bacteriological proofs.

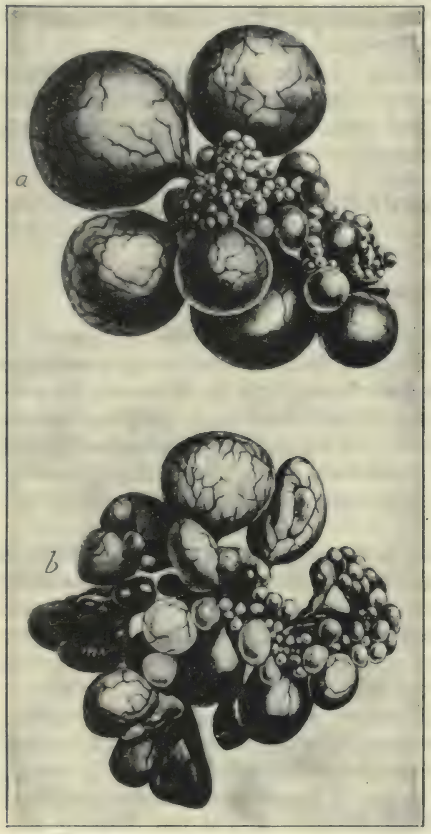

FIGURE 1.—*a*, Normal ovary of fowl; *b*, ovary affected with *Salmonella pullorum*. (After Rettger.)

Pullorum disease is observed in chicks from the time of hatching until they are about 3 weeks old. The chicks may die suddenly after having shown but slight symptoms for a short time. Generally, however, they will first seem disposed to huddle together, or remain too much of the time under the hen or the hover. They soon appear drowsy and indifferent to their surroundings. They stand about with closed eyes and ruffled plumage, listlessly picking at their feed from time to time, but apparently not eating it. Their droppings may be whitish, foamy, and sticky, or sometimes brownish in color. Hence the name "bacillary white diarrhea" is in some cases an inaccurate description of the disease. Sometimes the excrement sticks to the down in the region about the vent and accumulates until it completely covers and plugs the opening. This condition, known as "pasting up behind", unless soon relieved, will quickly cause the death of the chick. When attempting to void the excrement sick chicks utter shrill cries of pain. Labored breathing signals the approach of death, which may then come quickly, or after a period of extreme prostration. The death rate in infected broods may range from 50 to 80 percent.

Post-mortem appearance.—In hens and pullets the outstanding change brought about by the disease is that seen in the ovary. In making an autopsy of fowls that have died, or when preparing fowls for the table, the ovaries should be examined for lesions of pullorum disease. In an infected ovary the partially or wholly developed yolks are angular in outline, shrunken, hard, and of an abnormal brownish or greenish color (fig. 1, b). At times yolks containing dark fluid are observed. The presence of *Salmonella pullorum* in the diseased ova can usually be determined by laboratory methods.

In chicks dead from pullorum disease the presence of noticeable changes depends somewhat upon the age of the chick at death. Those from 1 to 5 days of age often fail to show visible internal evidences of the disease. Chicks dying at 6 days of age and upward very often show small necrotic spots, like whitish deposits, in the lungs, in the muscles of the heart, and possibly on the outer surface of the intestines. The absence of any pathological changes on autopsy does not, however, mean that the disease is not present. The germs sometimes inhabit practically every organ in the chick's body, but they are most frequently recovered from the heart, liver, lungs, the unabsorbed portions of yolk, and from the blood. Determining the presence of this infection in fowls of any age requires special training as well as the use of equipment and materials not generally available outside the laboratory. It is usually possible to have an expert examination made of suspected cases of pullorum disease at any of the State agricultural experiment stations.

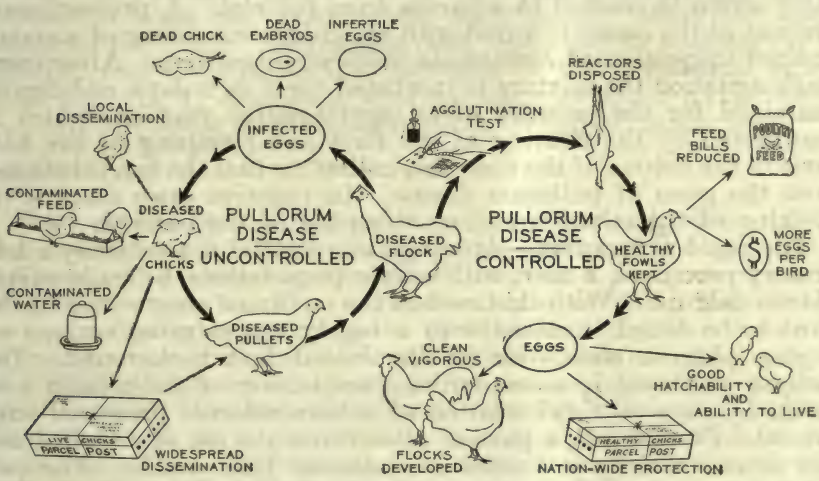

FIGURE 2.—Graphic comparison of serious effects of uncontrolled pullorum disease with the benefits resulting from the use of the agglutination test and the disposal of reactors.

Control.—There is no medicinal treatment, or method of vaccination which is of known value in the prevention or cure of pullorum disease in chicks or hens. The very nature of the disease renders treatment both futile and undesirable. Flocks which harbor the infection should not be used for breeding purposes. The cycle of infection established by the hen, the egg, the recovered baby chick, and the pullet (fig. 2) indicates that it is not advisable to save for breeders any chicks which have been exposed to an outbreak of pullorum disease. Hens which harbor the infection in their ovaries are likely to lay infected eggs from which diseased chicks will be hatched. The only practicable means of controlling pullorum disease, therefore, is to detect the carriers and eliminate them from the flock. The premises should be thoroughly cleansed and disinfected.

Methods of diagnosis of pullorum disease.—Various methods have been developed for the detection of carriers of pullorum disease in flocks. The decision as to which method shall be adopted in a given case will depend largely upon the kind of service available.

The agglutination test.—Three different forms of agglutination tests are in use at the present time: (1) The long method, or tube test, (2) the rapid serum method, and (3) the rapid whole-blood method. For practical purposes these three methods may be considered equally reliable for the detection of pullorum-disease carriers.

The long method, or tube test.—This method of testing is strictly a laboratory procedure and is not adaptable to field use. A small sample of blood is collected from each fowl to be tested, and the clear serum is allowed to separate from the clot. A proportionate amount of the serum is mixed with an antigen consisting of a standardized suspension of *Salmonella pullorum* organisms. After thorough agitation the mixture is incubated for 1 to 2 days, and finally examined for the presence of an agglutination reaction, which is manifested by the clearing of the fluid and clumping of the bacteria in the bottom of the test tube, indicating that the hen is infected with the germ of pullorum disease. In negative cases there is no clearing of the mixture, and no clumping of the bacteria.

The rapid serum test.—Although this method is essentially a laboratory procedure, it may, with certain preparations, be made adaptable to field use. With this method the undiluted clear serum of the fowl to be tested is mixed with a highly concentrated antigen on a glass plate or slide, over an illuminated dark background. The antigen employed is a standardized suspension of *Salmonella pullorum* in a concentrated solution of sodium chloride preserved with phenol. For the test, a pane of glass forms the top of a black-lined box illuminated by a frosted incandescent bulb within. The two substances are mixed by the aid of a toothpick. The reaction may occur immediately, or may require several minutes. A positive reaction consists in the formation of visible clumps of the bacteria and a clearing of the intervening fluid. A negative test remains uniformly cloudy, without any clumps forming.

The rapid, whole-blood test.—This test is somewhat similar in its mechanism to the rapid serum test previously described, but owing to its simplicity and facility of operating, it is well adapted to field use. Outstanding advantages of the rapid, whole-blood test are as follows: (1) The use of a single drop of fresh, whole blood immediately after it is obtained from the fowl; (2) the stained antigen, which makes it easy to detect reacting cases over a white background without artificial illumination; and (3) the fact that the presence or absence of pullorum infection is immediately diagnosed with one handling of the fowl and reactors are disposed of at the time of the test, eliminating the necessity of banding the fowls.

The antigen for the rapid, whole-blood test is composed of a heavy suspension of *Salmonella pullorum* in physiological saline solution preserved with formalin and stained with crystal violet.

In the application of this test a drop of blood is obtained by pricking the wing vein with a sharp-pointed instrument. The drop of blood is picked up with a wire loop and immediately mixed with one drop of stained antigen on the test glass or plate. The antigen is usually placed on the glass first, and the drop of blood is added to it. With the same wire loop, the antigen-blood mixture is stirred for a moment and then spread out on the glass to a diameter of about 1 inch. When the glass is rocked from side to side a few times, over a sheet of plain paper or other white background, the agglutination usually becomes visible in from 5 seconds to 2 minutes in reacting cases. The loop is then rinsed in clean water and dried on a clean towel in preparation for the next test.

The intradermic test.—This method consists in injecting into the wattle a small amount of a diagnostic agent prepared from a broth culture of *Salmonella pullorum.* In applying the test, the fluid is injected between the layers of the skin, slightly above the lower border of the wattle. In reacting cases an edematous swelling of the injected wattle similar to that produced by the intradermic tuberculin test (fig. 4) appears in approximately 24 hours. This test is generally regarded as less accurate than the agglutination test.

FOWL CHOLERA

Fowl cholera is a highly infectious, rapidly fatal disease of all domesticated birds. Birds of any age are susceptible.

Cause.—It is caused by *Pasteurella avicida*, a germ which multiplies to enormous numbers in the blood and various organs of the body, producing a septicemia or blood poisoning. The disease is carried by sick or recently recovered birds which have been placed in a healthy flock, by wild birds, or by persons, animals, or poultry utensils which have been on infected premises. It spreads rapidly throughout the flock, owing to the fact that the first birds to become infected give off great numbers of the germs in their droppings and these are picked up by the other birds in feeding and drinking.

Symptoms.—The first symptom is a yellowish coloration of the droppings. This is followed by yellowish, brownish, or greenish diarrhea. The bird becomes droopy, feverish, and sleepy and sits with the head drawn down to the body or turned backward and resting in the feathers about the wing. Appetite diminishes, and thirst increases. Breathing becomes difficult and may be heard at some distance. Finally the weakness is such that the bird cannot stand but lies with the beak resting on the ground. It sleeps so soundly for some time before death that it can hardly be aroused. The comb and wattles may be a dark-bluish red, and the skin of the breast and abdomen is frequently reddened.

In very acute cases no symptoms are seen; the birds may be found dead under the roosts or they may fall while feeding or moving about and die in a short time. During an acute outbreak sickness is seldom noticed more than 24 hours before death, which usually occurs within 3 days of the time of infection.

Cholera may destroy the greater part of a flock in a week and then disappear, or it may linger in a chronic form for months, only occasionally killing a bird. The chronic form is characterized by a continually increasing weakness, loss of weight, paleness of head, and finally an exhausting diarrhea. Sometimes one or more joints of the wings or legs swell, the bird becomes lame, and later the swellings break and discharge a creamy or cheesy mass.

Post-mortem appearance.—The heart has red spots or hemorrhages on its surface. The first portion of the intestines is congested and hemorrhagic, and the contents consist of a pasty mass, which may be bloodstained. The vessels of the visceral organs are congested. The liver may be enlarged and darker in color and the spleen may be swollen. A sticky fluid is frequently present in the mouth and nostrils.

Control measures.—Since treatment of affected birds is futile, the aim should be to prevent, so far as possible, the spread of infection. The first fowls showing acute feverish symptoms should be destroyed by a method which will guard against the contamination of the premises by infected blood. The carcasses should be burned or buried deeply. The healthy fowls should be moved to new quarters, if possible, and carefully watched for signs of the disease. Houses and runs should be thoroughly cleaned at frequent intervals and disinfected with a reliable disinfectant in proper dilution. The drinking water may be made antiseptic by adding one-third teaspoon of permanganate of potash to each gallon, a procedure which tends to check the spread of disease by means of the water.

Too much dependence, however, should not be placed on the permanent effectiveness of antiseptics in drinking water. If the feed or water supply of the fowls becomes contaminated, it should be removed and a fresh clean supply substituted.

EDEMA OF THE WATTLES

Edema of the wattles is a local swelling caused by their filling up with a dropsical fluid. The condition is caused by a localized infection with the germ of fowl cholera. Although the death rate from this disease is not high, the birds thus affected (principally males) are weakened and thus rendered comparatively defenseless against the attacks of more vigorous birds.

Keeping an antiseptic, such as permanganate of potash, one-third teaspoon to each gallon, in the drinking water is of some value in checking the spread of the disease by that means. The cropping (surgical amputation) of the wattles has been found to be more practical, however. The wattle is grasped firmly with a strong-jawed clamp and severed with clean scissors. Before the clamp is removed, the cut edges of the stump should be painted with tincture of chloride of iron to prevent hemorrhage. A dusting powder of equal parts of calomel and powdered burnt alum may be applied later to prevent subsequent hemorrhage or infection. The bird should be isolated, if possible, until the wounds are healed.

FOWL TYPHOID

Fowl typhoid is an infectious disease of mature chickens which has rarely been observed in other domestic birds. It attacks the blood and internal organs.

Cause.—The disease is caused by *Salmonella gallinarum*, a microorganism which is introduced on the premises by carriers such as infected fowls, material from infected poultry yards, or free-flying birds, or on the feet of persons or animals which have been on infected premises. Fowl typhoid spreads through a flock in a manner similar to fowl cholera and most of the other infectious diseases, but is not so destructive as the acute form of cholera.

Symptoms.—These are drowsiness, fever, loss of appetite, and general weakness. The droppings are soft and yellowish or greenish. The membranes of the head, comb, and wattles are usually paler than normal, but in acute cases may be darkened with venous congestion. Complete prostration may develop in from several hours to 1 or 2 days before death. Symptoms become noticeable in from 4 to 6 days after infection takes place and last, in fatal cases, from 4 to 12 days.

Post-mortem appearance.—The internal parts of the body other than the liver and the spleen have a pale appearance. The mucous membrane or interior lining of the intestine is usually pale. The blood is thin, pale red in color, and does not clot readily. The liver is greatly enlarged and generally dotted with grayish spots. It has a tendency to break easily. The spleen is often swollen, pulpy, and filled with grayish spots. The kidneys are somewhat enlarged and lighter in color or slightly congested. The heart appears normal or pale, with grayish spots on its surface.

Control measures.—The measures advised for cholera apply also to typhoid since medicinal treatment is of no value.

FOWL TUBERCULOSIS

Fowl tuberculosis is a chronic, infectious disease of domestic and wild birds. It is most common, however, in the chicken and pigeon. It is readily contracted by pigs, rats, and mice, but man is rarely affected by fowl tuberculosis. Parrots and canaries are quite susceptible to human tuberculosis, but fowls are practically insusceptible.

Cause.—The disease is caused by *Mycobacterium tuberculosis avium.* Tuberculosis is generally brought into the poultry yard with fowls that are purchased from infected flocks. If the disease exists in neighboring flocks the contagion may be carried by small birds, animals, or persons passing from one yard to another. A peculiarity of tuberculosis of birds is that the liver and intestines are nearly always very severely affected, and that as a consequence the organisms are very numerous in the intestinal contents and are scattered with the droppings. The introduction of a single diseased bird, therefore, may cause the infection of the greater part of the flock in a few weeks. In the same way, when wild birds contract the disease, the germs are carried and deposited in yards which they visit.

Pigs, rats, and mice are especially liable to be infected with fowl tuberculosis by eating the carcasses of birds which have died of it, and these animals serve to keep up the contagion and may communicate it to other fowls, especially if the latter eat the carcasses of rats or mice that have died of the disease.

Symptoms.—Although birds may become infected at any age, the disease usually progresses slowly, and symptoms are generally not observed until the affection has reached an advanced stage. Hence it is the older fowls, those more than 1 year of age, which display the most pronounced symptoms and show a high death rate.

Signs of disease begin with gradual loss of weight, wasting of the muscles, especially noticeable in the breast, paleness of the comb, and toward the end, dullness, sleepiness, and diarrhea with yellowish or greenish droppings. Very often there is at the same time a tuberculous inflammation of the joints and of the sheaths of tendons, which is revealed by lameness and swelling of the joints and legs. Occasionally the skin over the swollen joint breaks, the interior of the joint is ulcerated, and a small quantity of cheesy material is discharged. Deaths in the flock occur at intervals. Affected birds may live only a short time after symptoms are noticed, or they may live for weeks.

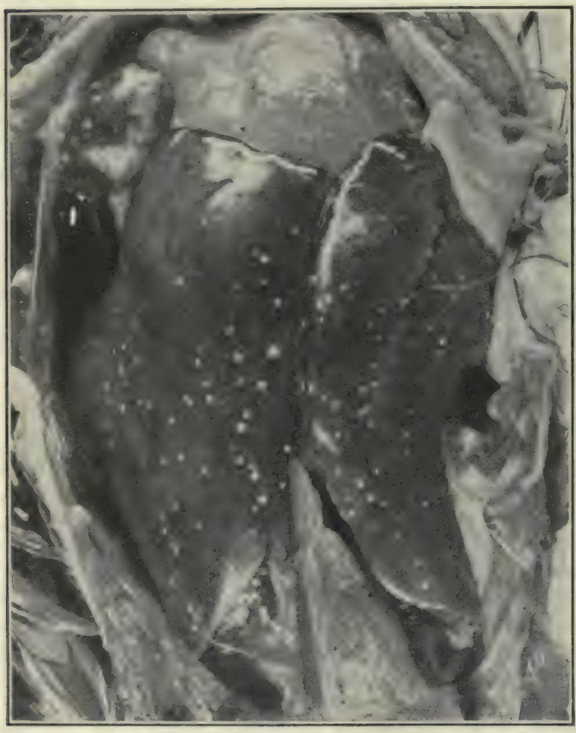
FIGURE 3.—Tuberculous organs of fowls. Note whitish spots on liver and its greatly enlarged condition.

Post-mortem appearance. — On post-mortem examination grayish-white or yellowish tumors of varying sizes are observed in the internal organs, but especially in the liver (fig. 3), spleen, and intestines. These tubercles when cut open present a solid, grayish, glistening interior which in the larger ones, exhibits yellowish centers or a number of yellowish points. Those of more advanced growth show extensive yellowish, cheesy, or crumbly masses in their interior.

Distinguishing tuberculosis from other diseases.—The diseases which may be confused with tuberculosis of birds by similarity of lesions are: Tumors or cancers of the abdominal organs, tapeworm nodules in the intestine, fungous condition of the lungs, blackhead of turkeys, blood poisoning which produces an enlarged, spotted liver, leukemia (big-liver disease), or gouty swelling of the joints. These diseases are described elsewhere in this bulletin. The prominent lesions of the conditions mentioned are usually limited, however, to certain specific organs instead of being spread to the variety of organs attacked in tuberculosis. A definite diagnosis may be had in all cases by microscopic examination of the disease processes. Avian tubercles contain extremely numerous tuberculous organisms which are readily seen in laboratory examination.

Testing fowls for tuberculosis.—Diagnosing tuberculosis in living fowls is possible by means of the intradermic tuberculin test. The test fluid used is prepared from bouillon in which avian tubercle bacilli have grown for several weeks. The fluid must be injected, by means of a small-caliber syringe with a 26- or 27-gage needle, into the deeper layer of the skin of the wattle. Slightly less than 1 drop, about one-twentieth of a cubic centimeter, is forced into the skin just beneath the surface, and not deep enough to penetrate the skin or enter the underlying connective tissue of the wattle. Only one wattle is injected, the other being left for comparison. Forty-eight hours after the injection, a swelling in the wattle indicates a positive reaction and the presence of tuberculosis in the fowl (fig. 4). A high percentage of tuberculous fowls in a flock may be detected by this test, which should be applied by a qualified veterinarian.

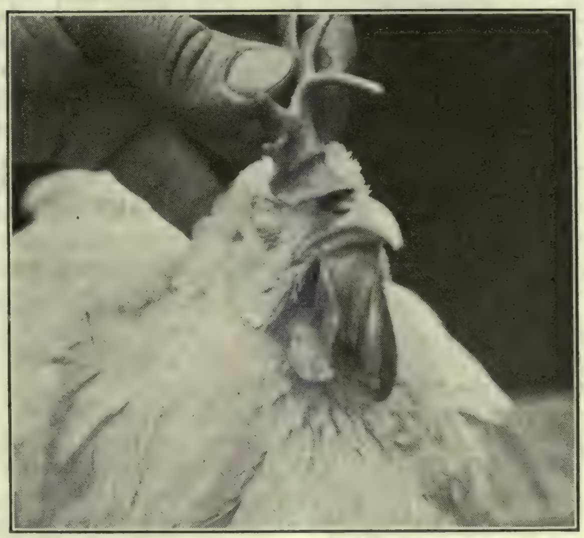

FIGURE 4.—Fowl showing swollen wattle, following tuberculin test, indicating the presence of tuberculosis.

Prevention and eradication. — No treatment will cure tuberculous birds. The most thorough method of eradication is to slaughter the entire flock when indications point to an extensive outbreak. Fowls in good flesh, showing no lesions or slight ones, may be used for food, provided all affected organs and parts are removed and the meat is thoroughly cooked. Those badly diseased and all visceral organs of the others should be destroyed.

The chicken houses, enclosed runs, and all eating, drinking, and other utensils should be thoroughly cleaned and disinfected as previously specified. After disinfection the premises should be kept free of fowls for a year, if possible, or new stock may be placed on ground which has not been occupied by poultry for a year or more. In restocking, obtain birds or eggs for hatching from flocks which have shown no signs of an infectious disease for a year or more. When the breeding value of the fowls makes it undesirable to dispose of the entire flock by slaughter, tuberculosis may be controlled and even totally eradicated by supplementing the customary culling measures with the tuberculin test and sanitation. As has been stated, the disease develops very slowly, and for that reason it is advisable to dispose of all birds when they reach the age of 18 months, or at the end of the first laying period. From an economic standpoint also this is sound policy, as the egg yield decreases after the first year of laying. Younger birds should be disposed of whenever they appear to be abnormal. This procedure alone will greatly assist in holding tuberculosis in check.

APOPLECTIFORM SEPTICEMIA

Apoplectiform septicemia is a rapidly fatal disease of chickens, turkeys, pigeons, and other fowl which is caused by the germ *Streptococcus capsulatus gallinarum.*

Symptoms.—Symptoms may consist of depression, inappetence, listlessness, staggering gait, and finally prostration and death. However, the progress of the disease is so rapid that death may occur without noticeable symptoms.

Post-mortem appearance.—There is usually a discoloration of the skin of the breast and neck caused by subcutaneous hemorrhages. Serous or bloody exudates may be seen in the heart sac and body cavity. The liver, spleen, and kidneys may be greatly swollen, and in addition a false membrane may be spread over the surface of the liver. The intestines are thickened and congested, with bloody contents. The lungs may be congested or pneumonic.

Control.—Observe the sanitary precautions outlined early in this bulletin. Healthy fowls may be successfully vaccinated against apoplectiform septicemia by the intravenous injection of a killed culture of the causative organism.

INFECTIOUS RHINITIS OF CHICKENS AND PHEASANTS

Infectious rhinitis is an infectious and contagious disease which spreads rapidly through poultry flocks, attended by variable mortality. Pheasants are also affected. The disease is caused by the germ *Hemophilus gallinarum.*

Symptoms.—The principal symptoms seen are those of a bloody or mucous exudate in the nasal passages and sinuses with or without mouth breathing. The membranes about the eyes may be swollen and inflamed, with a foamy tear formation of the affected eye. This tends to dry and stick the eyelids together. Some cases manifest a generalized edema of the region of the head and neck. There is initial fever, loss of appetite, emaciation, and sometimes coma and death. Mortality, which is apparently due to some toxic principle, may be especially high in young fowls.

Prevention and control.—General sanitary measures should be observed. Irrigation of the nasal passages with solutions similar to those recommended in this bulletin for the treatment of roup has been reported to give relief.

DISEASES CAUSED BY FILTRABLE VIRUSES

FOWL POX (DIPHTHERIA)

Fowl pox and diphtheria are but external and internal manifestations, respectively, of the same disease. The virus which causes the formation of warts or pox nodules on the head, typical of fowl pox, also causes the cheesy patches in the mouth and eyes which are characteristic of diphtheria. Chickens and pigeons are most frequently affected, but turkeys and birds generally are susceptible.

Cause.—Fowl pox is caused by a virus which passes through laboratory filters and cannot be seen even with a powerful microscope. The disease is strictly infectious and never develops as a result of exposure to dampness and drafts alone, although these conditions favor its spread and tend to increase its malignancy. The contagion is introduced and disseminated in a flock in the same manner as fowl cholera. It is probable that biting insects, such as mites, also spread infection, through inoculation, from sick to healthy birds.

Symptoms.—The disease has the general symptoms of roup but is distinguished from it by an eruption of pox nodules on the head and by the presence, in the mouth, throat, and eyes, of tough, cheesy patches which are firmly attached to the tissues beneath them (fig. 5).

The eruption appears as round, oblong, or irregularly shaped nodules from the size of a pinhead to that of a pea or a hazelnut. It is seen especially about the beak and nostrils and on the comb, the eyelids, the wattles, and the ear lobes. In some birds, particularly in pigeons, the eruption is more generalized and is found on the skin of other parts of the body, as the neck, under the wings, on the rump, and about the vent. Here the nodules may become larger than on the head. The nodules begin as small, red, or reddish-gray growths with a shiny surface and gradually enlarge, while the color changes to a yellowish, brownish, or dark brown, and the surface dries and becomes shriveled, uneven, and warty in appearance. Owing to the number of nodules and the extension of the inflammation, large patches of skin become thickened and covered with hard, dry crusts, closing the nasal openings or the eyelids, and making it difficult to open even the beak.

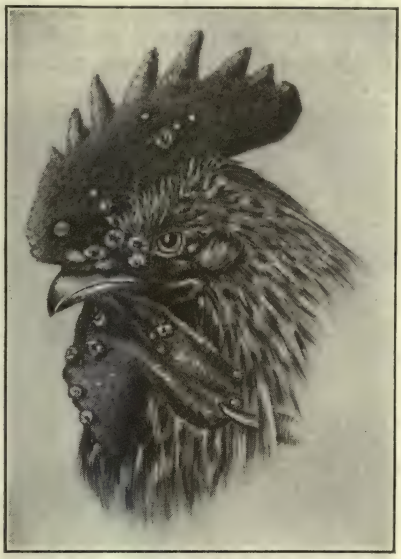

FIGURE 5.—Fowl-pox nodules on comb, on wattles, and near corner of mouth. (After Hutÿra and Marek.)

The severity of the disease depends much on the extent of the internal diphtheritic deposits (fig. 6). These are at first thin, yellowish or whitish in color, and gradually become thicker, firmer, and more adherent, so that considerable force is required to remove them. The mucous membrane beneath the deposit, when the latter is removed, is found to be inflamed, ulcerated, and bleeding, but it is soon covered by a new deposit. This exudate is called a false membrane, and when it is situated where the breathed air passes over it, it dries, becomes uneven and fissured, and its color changes to a dark brown. In pigeons the exudate is more friable and easily removed, and the mucous membrane beneath it is reddened but not ulcerated.

While the false membranes over the parts first affected are becoming thicker, the inflammation extends to the adjoining surfaces, and new diphtheritic centers develop, uniting with one another until the cheeks, tongue, palate, throat, and inside of the nostrils are covered. Very often the inflammation extends from the nostrils to the eyes, and sometimes it penetrates the air tubes to the lungs, or the gullet to the crop. When false membranes form in the gullet, crop, and intestines there is a rapid aggravation of the symptoms, such as intense diarrhea, and the escape of blood with the droppings. This type of the disease is more frequent in waterfowl than in other birds. Some fowls in a flock are resistant, and after a few days of illness rapidly recover. Others remain dull weak, and thin in flesh, and may have more or less catarrh and difficulty of breathing for a long time.

The period between exposure to the contagion and the appearance of the first symptoms varies from 3 to 15 days. The duration of the disease varies from 2 or 3 days to as many weeks in the acute cases, while the chronic form may continue for several months.

Treatment.—The treatment of fowls severely affected with diphtheria requires much time and patience, and as a rule does not pay. It is often better to kill the birds, bury or burn their carcasses, and disinfect the poultry houses, and in that way eradicate the contagion as soon as possible.

If it is decided to treat the sick birds they should be removed from the flock and put into a comfortable, well-ventilated room that may be easily disinfected. Remove from the mouth or larynx the false membranes which interfere with eating or breathing, and apply tincture of iodine or argyol. If the eyesight is threatened by large swellings under the eyes, open the swellings, remove the cheesy pus, and apply either of the disinfectants mentioned.

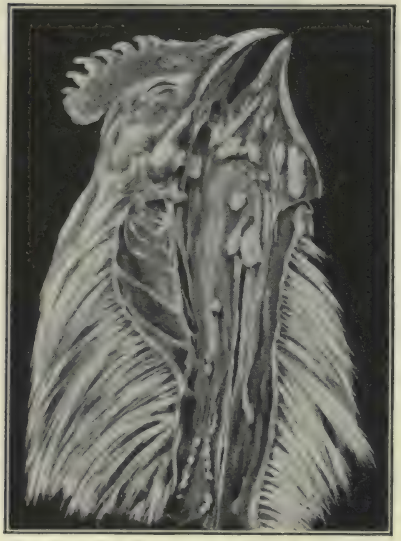

FIGURE 6.—Diphtheria. Neck slit open to show diphtheritic patches in mouth and esophagus. (After Rátz.)

As this disease is contagious, the houses, drinking vessels, and feed troughs should be kept disinfected during the outbreak and for several days after all the birds have apparently recovered. The drinking water is made antiseptic by dissolving one-third of a teaspoon of permanganate of potash in each gallon.

Prevention.—In order to diminish the possible interference with the productivity of the flock, the birds should be vaccinated at 3 to 5 months of age. Vaccination of a flock of poultry is not recommended, however, under any circumstances, unless the disease has been known to exist on the premises, or the owner considers that his flock is in danger from infection in neighboring flocks. Neither should chickens be subjected to the ordeal of vaccination when in a debilitated, sickly condition, or when heavily infested with parasites. Show birds or those in egg-laying contests should be immunized against pox 6 weeks before being sent to exhibitions or contests.

There are two methods of vaccination; the "stab", or "stick", method and the "follicle" method. The stab method is a more recent development and seems to have several advantages over the older follicle method; vaccination can be accomplished much more easily and quickly, much less vaccine is required, and it is more sanitary.

In the stab method a narrow, sharp-pointed knife or lancet with adhesive tape wrapped around the blade about one-eighth inch from the point is used. Vaccination is accomplished by dipping this instrument into a bottle of vaccine and making a quick stab sufficient to penetrate the skin. The most convenient site to vaccinate by this method is on the outside of the leg near the "knee" (patellar) joint where the rows of feathers are far apart and the stab can easily be made between the rows.

A variation of the stab method recently reported is the use of two sewing-machine needles pushed through a cork with the points about one-fourth inch apart. When this instrument is used the wing is stretched out and the web is pierced from the under side, thus making four vaccination points through the double layer of skin simultaneously. The eyes of the needles retain sufficient vaccine to make it effective.

When vaccinating is done by the follicle method the procedure is as follows: Pluck out several feathers from the front part of one leg, and with a cropped, bristle brush, or other suitable applicator, rub the vaccine into the empty feather follicles.

The reaction denoting a so-called "vaccination take" may be noticed in 2 or 3 weeks. The site of vaccination will show inflammation and later the formation of a scab, which will drop off in from 20 to 30 days.

Some investigators in Europe and the United States have advocated the use of the virus of pigeon pox for the vaccination of chickens against fowl pox, claiming for this method the establishment of a satisfactory immunity with no appreciable disturbance of health or egg production.

INFECTIOUS BRONCHITIS (INFECTIOUS LARYNGOTRACHEITIS, INFLUENZA, "FLU")

Infectious bronchitis is observed among chickens during the fall and winter months, especially in the large, central, poultry-feeding establishments of the Middle West, and during the shipment of the fowls by rail to the principal poultry markets.

Cause.—The disease is caused by a filtrable virus.

Symptoms.—Difficulty in breathing causes the bird to extend the head and open the beak for each respiration (fig. 7), and there is usually a rattling noise caused by obstruction of the windpipe. The bird becomes ruffled and unkempt. The facial expression is distressed. Appetite rapidly diminishes. Sticky exudates in many cases are present in the mouth and nasal cavity.

Affected birds may recover, although many die within 3 or 4 days after exposure, or may succumb after a week or 10 days. Death is usually caused by asphyxiation from the mechanical obstruction of the windpipe with dry, cheesy exudates. These are, as a rule, more darkened and fibrinous than those of diphtheria, and are found only in the air passages.

Post-mortem appearance.—Autopsy reveals no significant lesions except an inflammation of the nasal tract and windpipe, which are obstructed with a mucopurulent or fibrinous exudate, frequently tinged with blood.

Treatment.—No satisfactory flock treatment is known. Individual cases have been benefited by the repeated removal of the dried exudative plug from the windpipe, and placing the sick birds in small groups in warm but well-ventilated quarters.

Control.—The control of this disease is favored by the application of such measures as cleaning and disinfecting the premises, isolating or destroying all sick birds, burying or burning all carcasses, and providing comfortable, spacious, and well-ventilated quarters for the flock.

The eradication of the disease necessitates the rigorous application of sanitary and hygienic precautions. The essential points of a plan of eradication of infectious bronchitis which is in use in Massachusetts are given in the following paragraph. This plan is especially adaptable to isolated outbreaks of the disease, or outbreaks occurring in areas where the poultry population is small or segregated in remote units.

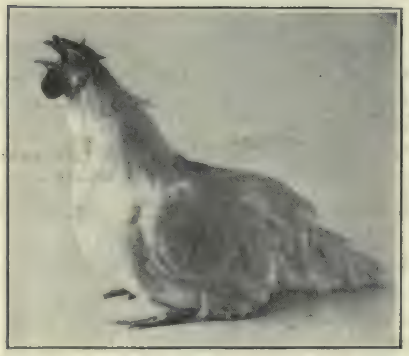

FIGURE 7.—Hen affected with infectious bronchitis, showing typical appearance due to difficult breathing. (Photo by J. R. Beach.)

Gather the required number of eggs for hatching and then dispose of the entire breeding flock which has been exposed to or affected with the disease. Cleanse and disinfect incubators and brooders, and remove them to a safe distance from the disease-infected premises. Use every sanitary precaution in hatching the eggs and brooding the chicks. Cleanse and disinfect buildings and equipment used by the diseased flock as soon as possible after their removal. Then open the doors and windows, allowing the air and sunshine to enter and let the houses remain vacant for 2 months or longer. No clothing or footwear worn around the diseased flock or their premises should be worn when working with the chicks for restocking, unless such apparel has been thoroughly cleansed or disinfected. Introduce new stock only from flocks known to be free of the disease, or raise chicks from your own safeguarded hatches. Safeguard the flock from the introduction of the disease by chickens from diseased flocks, visitors from contaminated localities, hucksters, stray dogs, and similar sources.

The New Jersey Agricultural Experiment Station has developed a vaccine for the prevention of infectious laryngotracheitis. This product is prepared by rapidly drying and pulverizing the tracheal exudates of affected fowls. The powder is mixed with a measured proportion of sterile fluid and is applied to the bursa of Fabricius (an invaginated sac adjacent to the cloaca) with a small bristle brush or swab. A temporary local reaction, about the fifth day, consisting of an inflammation of the vaccinated area, shown by redness and swelling, is regarded as an indication that the vaccination was successful.

This vaccine should not be used in flocks except where the disease has already existed or is dangerously prevalent in the vicinity, since the introduction of the living virus in this way may produce the active disease, and necessitate future vaccinations on the premises. Debilitated birds or birds less than 6 weeks of age should not be vaccinated against this disease.

FOWL PEST

Fowl pest, also known as European fowl pest, is a very acute infectious disease. It is of rare occurrence in the United States, only a few outbreaks having thus far occurred in this country. All were eradicated. The disease affects particularly chickens, turkeys, and geese. Blackbirds, sparrows, owls, hawks, and other birds also contract the disease, but wild waterfowl and pigeons are resistant. Mammals, including human beings, are not susceptible.

Cause.—The infective agent is a filtrable virus which is present in the blood and various tissues of the bird.

Symptoms.—The disease is characterized by its extremely infectious nature, rapidly progressing course, and high mortality. The infected fowl loses its appetite, has an irregular gait, and becomes very droopy. The feathers are ruffled, and there is considerable prostration, with swelling and darkening of the comb and wattles. A sticky exudate may paste the eyelids together, clog the nasal passages, and even obstruct the windpipe, causing labored breathing. Some affected birds shake their heads periodically in order to dislodge this mucous secretion from the throat and nostrils, at the same time producing a peculiar, wheezy sound. The bird lives, as a rule, for from 2 to 5 days, occasionally 6 or 7. In the very acute form of the disease the bird may be apparently in good condition in the morning and be found dead in the afternoon.

Post-mortem appearance.—On post-mortem examination of acute cases lesions may be entirely lacking. In the less acute cases—that is, in those that live for 3 or 4 days—there is a mucous exudate in the nostrils, larynx, and windpipe, with bloodstained patches and sometimes blood clots in the windpipe. The lungs are usually more or less pneumonic. A hemorrhagic or bloodshot condition is found on the crop and under the skin in various other parts, sometimes accompanied with a gelatinous substance. Hemorrhagic spots on the muscle and sac of the heart, on the gizzard fat, on the outer surface of the small intestines, and especially on the inner lining of the two stomachs, the glandular stomach and the muscular stomach, or gizzard, are typical of fowl pest. These little hemorrhagic patches may be found along the entire intestinal canal, with considerable catarrhal condition, and when that is marked the bird has a profuse diarrhea, but the latter is not always present. A serous fluid is sometimes seen in the heart sac, or in other cases in the body cavity.

Control measures.—As the disease is incurable, control measures should be essentially the same as those recommended under the discussion of fowl cholera. In addition, infected shipping and receiving centers, fattening plants, chicken crates, and live-poultry cars should be thoroughly cleaned and disinfected under official supervision.

DISEASES CAUSED BY FUNGI (MOLDS)

ASPERGILLOSIS

Aspergillosis is a fungous disease of the lungs and air sacs which may affect any of the domestic birds and is quite prevalent in birds confined in zoos or other aviaries. It is regarded as one of the causes of brooder pneumonia in baby chicks.

Cause.—The causative agents are the common green mold, *Aspergillus fumigatus*, and the black mold, *A. niger*, which grow on vegetables and other kinds of matter. Warmth and moisture favor their development. When moldy hay, straw, or chaff is given to the fowls to scratch in, or moldy grain is fed, the spores of the fungi are inhaled by the birds.

Symptoms.—This disease may be limited to a single bird, or it may assume the form of an extensive outbreak among adult fowls. Occasionally, it may cause a brooder pneumonia among chicks, but this should not be confused with brooder pneumonia due to pullorum disease. When the air tubes or lungs are attacked, the first symptom is a slight catarrh, with accelerated breathing. Soon the swellings obstruct the passage of air, and there is a rattling or croupy sound heard chiefly during expiration. The affected birds mope, separate themselves from the remainder of the flock, or remain in a sitting posture; if made to move, they appear weak and scarcely able to walk, and if they try to run they soon fall from exhaustion. The difficulty of breathing increases rapidly; they gasp for breath and make movements of the head and neck as if choking; there are fever, diarrhea, drooping wings, great depression, a tendency to sleep, and finally suffocation and death.

When the disease is limited to the large air sacs the only symptoms are weakness and progressive loss of flesh. If the small air sacs of the bones are involved there may be lameness, with swollen and inflamed joints. The symptoms in brooder chicks are similar to those of pullorum disease. Aspergillosis is always fatal. Young chicks die within a few days. Older birds may live from 1 to 4 or more weeks after the appearance of symptoms.

Post-mortem appearance.—The walls of the windpipe, air passages in the lungs, and air sacs in the body cavity show whitish or yellowish nodules in the early stages of the disease. Later the walls are covered by elevated, dirty-yellow, or greenish layers, which represent growths of the mold, and the air sacs may become completely filled with firm yellow pus.

Prevention.—The disease is prevented by giving only clean and bright straw or chaff for the fowls and brooder chicks to scratch in, by keeping the houses and yards clean, and seeing that all grain and meal fed are sound and entirely free from mold. The sick birds should be removed from the flock, and the bodies of those which die should be burned or buried.

THRUSH

Thrush is an infectious disease of the mouth and crop, and sometimes of the esophagus and glandular stomach, of young chickens, pigeons, turkeys, and geese. The disease is caused by the fungus

Oidium (*Saccharomyces*) *albicans* and is manifested by the formation of grayish-white or yellowish patches on the mucous membranes of the parts named. These patches may eventually enlarge and coalesce. A slimy discharge may drool from the mouth of the affected bird. Loss of appetite and consequent weakness and emaciation attend the disease.

Treatment.—The sick birds should be isolated. The visible thrush deposits in the mouth and throat cavities should be removed with forceps, and the erosions painted with glycerin-iodine solution (tincture of iodine, 1 part; glycerin, 4 parts). If the crop is affected it may be flushed out with a 2-percent boric acid solution. The quarters and equipment should be cleaned and disinfected.

FAVUS (WHITE COMB)

Favus of fowls is a contagious disease that begins with the formation of grayish-white spots on the comb, ear lobes, or wattles.

Cause.—This disease is caused by a fungus called *Lophophyton gallinarum* and is transmitted from fowl to fowl by simple contact.

Symptoms.—Favus generally begins on the bare parts of the head as small, white, or grayish spots, which increase in number and size until the whole surface is covered with dry, scaly, dirty-white crusts with an irregular surface. As the disease advances the neck and body are gradually invaded, and the feathers become brittle and break off, leaving a deep depression in the center of a cup-shaped disk. The disease when limited to the comb and wattles may disappear without treatment, but after it has invaded the feathered parts it almost invariably continues to advance, and the birds grow weaker until they die.

Treatment.—When only the bare parts of the head are affected, the disease may be cured by daily applications of tincture of iodine to the diseased areas. It is essential to separate the affected bird from the flock. If the feathered parts of the body are affected, it is advisable to kill the bird.

DISEASES OF UNKNOWN CAUSE

ROUP

Roup attacks principally the eyelids, the sacs below the eye (infraorbital sinuses), the nostrils, and the windpipe (fig. 8).

Cause.—The specific cause of this disease has not yet been definitely determined. Exposure to cold, dampness, and drafts, and also crowding and poor ventilation, aid in the development of roup.

Symptoms.—The first symptoms are very similar to those of an ordinary cold, but there is more fever, dullness, and prostration. The discharge from the nasal openings is at first thin and watery, but in 2 or 3 days it becomes thick and has an offensive odor. The inflammation, which begins in the nasal passages, soon extends to the eyes and to the spaces immediately below the eyeballs, causing the formation of swellings which may reach the size of a hickory nut. The resulting pressure sometimes destroys the eye, or causes permanent loss of vision. The eyelids are swollen, held closed much of the time, and may be glued together by the accumulated secretion. The closing of the eyes prevents the badly affected birds from finding food. The accumulation of mucus in the nostrils completely obstructs these passages so that the beak must be kept open to permit breathing. The obstruction of the windpipe and of the smaller air tubes causes difficult respiration, accompanied by loud breathing. In severe and advanced cases the birds sit in a drowsy or semiconscious condition, unable to see or eat; their strength is rapidly exhausted, and many of them die within a week or 10 days. Some of the affected birds recover, but others remain weak and have a chronic form of the disease for months.

This disease is distinguished from diphtheria (fowl pox) by the absence of the thick, tough, and very adherent cheesy exudates in the mouth and throat which are characteristic of the latter disease. Sometimes there may be a deposit of yellowish material on the walls of the mouth and throat, but it is easily broken up and removed. There are no warts on the comb, face, or wattles.

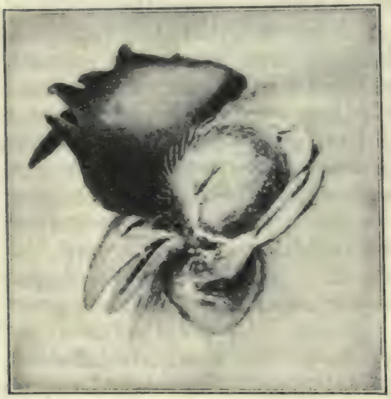

FIGURE 8.—Head of fowl affected with roup, showing swelling of the eye.

If mouth breathing is long continued, it eventually brings about a horny, dried condition of the tip of the tongue, commonly referred to as "pip", unless that is prevented by anointing the tongue with petrolatum or a bland oil.

Treatment. — The sick birds should be removed from the flock and put in a warm, dry, well-ventilated room free from drafts. The affected mucous membranes of the nostrils and mouth should then be irrigated with antiseptic solutions. The best method is to use a good spraying apparatus, but a small syringe, an oil can, or even a medicine dropper will serve the purpose. Another method is to plunge the bird's head into a basin or bowl of the solution and hold it there a few seconds, but not long enough to cause suffocation.

The antiseptics most suitable for such treatment are: Boric acid 1 ounce, water 1 quart; or permanganate of potash 2 drams, water 1 pint; or peroxide of hydrogen 1 ounce, water 3 ounces. When the inflammation has progressed to the eye, excellent results have followed the use of argyrol, one or two drops of a 15-percent solution being placed between the eyelids twice daily for several days.

Before applying any of these substances it is well to wash the eyes and mouth with warm water containing 1 teaspoon of common salt to a quart, using a pledget of absorbent cotton and rubbing gently, at the same time pressing and massaging about the nostrils and under the eyes to loosen the accumulated secretion. If there is a swelling under the eye, it should be carefully opened with a sharp, clean knife, all the excretion removed, and the cavity washed with one of the above-mentioned solutions. A pledget of cotton moistened with the solution may be left in the opening for an hour or two.

Various types of germs have been observed as secondary invaders in the eye exudates of roup. Bacterins prepared from strains of

Staphylococcus aureus recovered from birds affected with roup have been used with good results in the control of this disease.

The houses should be kept clean and dry and occasionally should be disinfected. If the disease is of a severe type, it is often better to kill the affected birds.

COLDS (SIMPLE CATARRH)

Simple catarrh is a mild inflammation of the nasal passages, and is common to all kinds of domesticated birds.

Cause.—No definite cause can be assigned to this affection. Weak or improperly nourished birds are more likely to be attacked than strong, vigorous, well-nourished individuals. Exposure to unfavorable conditions such as crowding, poor ventilation, dampness, and cold drafts, tending to lessen the resistance of the mucous membranes of the nostrils to the various organisms normally present there, has been held to be the primary contributing cause.

Symptoms.—The affected bird is more or less dull in appearance, the appetite is diminished, breathing becomes difficult, and a watery discharge from one or both nostrils is early in evidence. This discharge may disappear in from 2 to 4 days, or it may take on a viscid consistency, closing the nasal openings and necessitating breathing through the mouth.

Treatment.—As the disease is of short duration, it is usually necessary only to place the bird under more favorable conditions to bring about recovery. In the more severe cases the nostrils should be washed out twice daily with boric acid in 4-percent solution, or with permanganate of potash, 1 dram (about a teaspoon) to a pint of water.

PARALYSIS (RANGE PARALYSIS, LYMPHOMATOSIS, LEUCOSIS)

The paralysis here described is a distinct disease, and must not be confused with the various types of paralysis, leg weakness, or lameness due to a deficiency of vitamins, infectious diseases, or parasites.

Birds may be affected between the ages of 6 weeks and a year or more, but the highest incidence of the disease occurs between the ages of 4 to 8 months. The mortality may be very high, in some cases reaching 50 percent or more.

Cause.—The cause has not been definitely determined. There is some evidence that the etiological agent is a filtrable virus and that the various disease manifestations (paralysis "gray eye", tumors, and leukemia) seen in paralysis-infected flocks have a common origin.

Symptoms.—There is at present no method of diagnosing the disease in live birds which will eliminate all the birds that may be carrying the agent causing the disease.

Two manifestations of the disease are commonly seen, paralysis of the limbs and gray eye. Perhaps the most common and most striking type is that in which the nerves to the legs or wings are affected, with resulting lameness or drooping of the wings. In acute cases in young birds on the range the onset may be sudden, the first noticeable symptom being a slight limp. The lameness usually becomes progressively worse so that the bird becomes prostrated in a day or two. Paralysis of the limbs is usually not complete, and the bird, although unable to stand, may still be able to kick when disturbed. A characteristic posture in the later stages of the disease is one in which the bird lies on the breast with one leg extended forward and the other backward. Either one or both legs or wings may be affected. In cases in which the wing is dropped, enlargement of the wing nerve may sometimes be noted at the point where it crosses the radius bone on the inside of the wing at the "elbow" joint.

Other less common symptoms of involvement of the nervous system are (1) torticollis, or spasm of the neck muscles causing the head to be drawn to either side, down between the legs, or straight back with the beak pointing up, and (2) incoordination, varying from a slightly weaving gait to falling or turning somersaults.

In gray eye there is a loss of the bay color in the iris ranging from a narrow pale ring around the margin of the pupil to total grayness of the iris, when the eye often presents a glassy appearance. In advanced cases the pupils frequently become irregular in outline, very small, or eccentric, and there may be bulging of the eyeballs. In advanced gray eye there is generally partial or complete blindness. Some birds with gray eye appear to be otherwise healthy and may lay fairly well. Gray eye is more often seen in mature birds.

Other symptoms of disease sometimes associated with paralysis outbreaks are skin tumors and anemia.

Skin tumors may be small and almost as numerous as the feather follicles, or there may be only a few large ones (1 inch or more in diameter), the centers of which are generally necrotic and discharging.

Anemia may be recognized by the extreme pallor of the head or by microscopic examination of the blood. If it is a true leukemia, the leucocytes, or immature blood cells, will be present in the blood in large numbers. This is the only type of the fowl-paralysis complex in which there is obvious alteration of the blood picture.

Acute attacks may terminate fatally in a few days, whereas birds affected with the chronic form of the disease may live for weeks or months; a few appear to recover.

Post-mortem appearance.—On autopsy of the paralyzed fowls it will be noticed that the nerve supplying the affected limb is swollen (fig. 9). The part of the nerve in which the swelling is most prominent is generally the first inch after its emergence from the spinal column, though sometimes the swelling is apparent all the way down the leg or wing to the nerve ending. It is usually necessary to remove the overlying kidney to observe the enlargement of the lumbosacral nerve plexus. The vagus nerves (fig. 9, *cc*), supplying the heart, lungs, and digestive tract, may show only spindle-shaped swellings just anterior to the heart, or uniform enlargement all the way to the head.

In the acute form of the disease which attacks young birds on the range the victims may be in good flesh, and post-mortem examination usually shows nerve enlargement, or tumor formation, frequently of the ovary. In the more chronic form of the disease the birds generally show extreme emaciation with atrophy of the internal organs, and diffuse hemorrhages in the muscles giving the flesh a dark red, mottled appearance.

Tumor formation (lymphocytoma) is a common lesion in paralysis-infected flocks and may be found on the skin or in the internal organs. The liver is frequently the seat of either diffuse or nodular tumor formations which may cause enormous enlargement of this organ up to 200 grams or more. This is commonly called "big-liver disease", or leukemia. However, it is not a true leukemia as an abnormal number of leucocytes are not observed on examination of the blood. The ovary, kidneys, heart, lungs, spleen, digestive tract, or any other tissue may be the site of tumor formation. These tumors are firm and fleshy in consistence and white or gray in color. In the nodular type the tumor may vary from the size of a pinhead up to that of a hen's egg. In the diffuse type of tumor the organ involved is enlarged, firmer in consistence than normal, and usually shows a mottled gray discoloration instead of the normal pink or red.

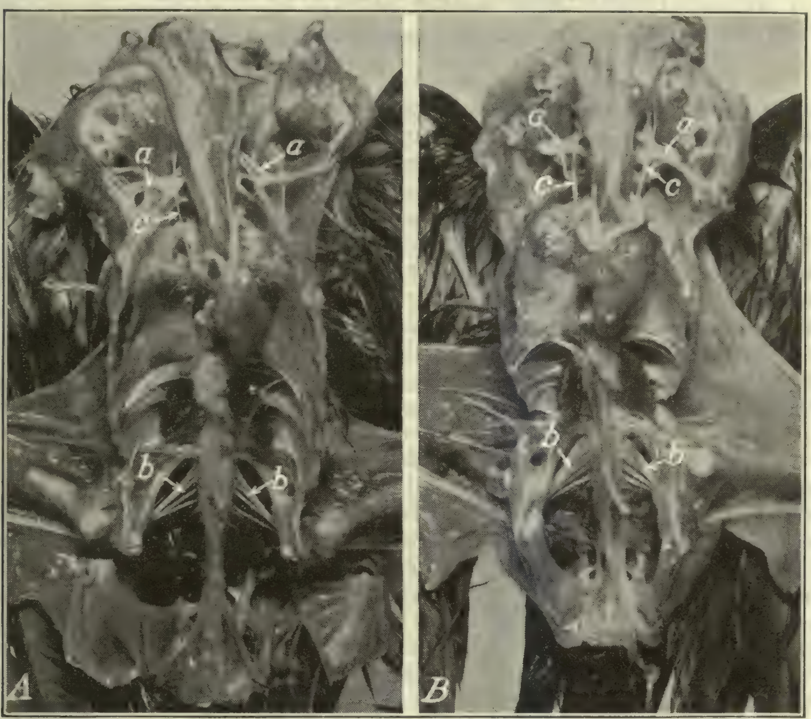

FIGURE 9.—*A*, Carcass of a fowl showing normal nerves (left vagus nerve not shown); *B*, carcass of a fowl dead of paralysis; *aa*, brachial nerves to wings; *bb*, lumbosacral nerves to legs; *cc*, vagus nerves to heart, lungs, and digestive tract. Note swollen nerves in carcass of fowl dead of paralysis.

Mode of transmission.—There is considerable evidence that this disease is transmitted through the egg. It is also thought by some investigators that it may be transmitted by the contact of healthy birds with infected birds or with contaminated surroundings.

Control.—Until more is known of the cause and mode of transmission of the disease only general control measures can be suggested. It is advisable to dispose of all birds showing symptoms of the disease and to clean and disinfect the premises and utensils thoroughly. All new stock brought in, including baby chicks, should be selected from sources known to be free from this disease and should be maintained apart from the original flock in which the disease occurred.

DISEASES OF THE DIGESTIVE ORGANS

IMPACTED CROP (CROP-BOUND)

The affection known as impacted crop or crop-bound is an overdistended and paralyzed condition of the crop, generally caused by overeating or by swallowing coarse and indigestible substances, such as feathers, or fibrous feeds, especially straw. In fowl cholera and some other diseases, the crop is paralyzed as a result of the disease.

Symptoms.—The first symptom is a loss of appetite, or an effort of the bird to swallow without being able to do so. The crop is very large and much distended, with contents more or less firmly packed together. If permitted to continue, the condition becomes aggravated, breathing is difficult, and death may result.

Treatment.—The contents of the crop may be removed sometimes by forcing the bird to swallow a teaspoon or more of sweet oil and massaging the lower part of the gullet, if it contains feed, or if not, the part of the crop nearest to the gullet, until the contents are softened and may be pressed toward the head. This is made easier by holding the bird head downward. By continued manipulation the greater part of the material may be removed. The bird should not be permitted to eat for several hours after it is relieved. If this treatment is not successful, the crop may be opened with a sharp knife and the contents removed through the opening, a coffee spoon, a buttonhook, small forceps, a bent wire, or other suitable instrument being used for this purpose. Then wash out the crop with clean, warm water. The opening should not be more than an inch in length and should be closed with 3 or 4 stitches, first in the wall of the crop and, when this is finished, by an equal number in the skin. Each stitch should be made and tied separately. Coarse, white silk is the best material, but if it is not available ordinary cotton thread may be used. Feed the bird for a day or two on milk and raw egg, beaten together, and gradually change to soft mash.

INFLAMMATION OF THE GLANDULAR STOMACH (PROVENTRICULITIS)

Inflammation of the glandular stomach is often seen in growing chicks reared in confinement, and occasionally in adult fowls.

It is generally due to dietary deficiency or some debilitating disease. It is characterized by a thickening of the wall so that the glandular stomach takes on a globular shape. The lining mucous membrane usually shows various stages of inflammation, ulceration, and atrophy of the digestive enzyme-secreting glands. This glandular atrophy results in poor digestion and emaciation.

This condition can be definitely diagnosed only on autopsy, but if chicks show emaciation in the absence of any other apparent cause, proventriculitis should be considered.

INFLAMMATION OF THE INTESTINES (ENTERITIS)

Enteritis is an inflammation of the lining (mucous) membrane of the intestines. It is not a distinct disease but results from some other condition, such as malnutrition, infectious diseases, or the presence of internal parasites.

This inflammation may vary in degree from a mild catarrh in which there is an excess of mucus and pus in the intestine to a severe hemorrhagic type in which there is capillary hemorrhage into the lumen and the intestinal contents are bloodstained. In severe chronic cases ulcers or erosions of the mucous membrane may develop so that digestion and assimilation of food are seriously interfered with and poisons are absorbed into the circulation. In other cases irritating substances in the diet may cause diarrhea.

Treatment.—This consists in diagnosing and treating the condition that caused the inflammation. If malnutrition is the cause, the diet should be balanced with proper feed, which should contain adequate amounts of the vitamins. All injurious and irritating substances such as sand, straw, or shavings should be removed when there is a tendency to depraved appetite. If parasites are the cause of the inflammation, measures should be taken to eliminate them. In most cases of enteritis medication is not advisable.

WHITE DIARRHEA OF CHICKS

White diarrhea is a commonly used term which covers various diseases of chicks from the time of hatching until the birds are approximately 1 month old. It merely indicates a common symptom, a whitish diarrhea, which is usually observed in sick chicks, no matter what the specific nature of the disease may be.

Cause.—Aside from specific infections which are discussed elsewhere in this bulletin, the principal cause of white diarrhea is a nonspecific fever accompanying colds, chilling, overheating, or intestinal disturbance from incorrect feeding or insanitary quarters.

Symptoms.—The disease may run a mild and transitory course, or it may progress in severity with aggravated symptoms approaching those of pullorum disease, which is described elsewhere in this bulletin.

Treatment.—Medicinal treatment of affected chicks is impractical. Corrective treatment consists in practical measures to remove the cause or causes indicated, and in general to secure, for the brood, clean and comfortable living conditions, including proper feeding, watering, and ventilation.

INDIGESTION

To digestive disturbance may be attributed numerous conditions, such as loss of appetite, pica (abnormal or depraved appetite), sour or hanging crop, impaction of the gizzard, diarrhea, and constipation.

Cause.—The principal causes are irregularities of feeding, such as feed that is too coarse, dry, or fibrous; moldy or decayed feed; access to poisonous plants or irritating chemicals; lack of grit in the gizzard; or polluted water supply.

Indigestion may also occur as a symptom of some diseases, such as catarrh of the crop or stomach, enteritis, and parasitism, in which cases special treatments should be given.

Treatment.—The ration should be clean, wholesome, nutritious, and easily digestible, supplemented by a constant supply of grit, charcoal, and crushed oystershell. For impaction of the gizzard or constipation, Epsom salts, 1 pound to each 10 quarts of drinking water, may be placed before the flock for 1 day instead of other drinking water; or castor oil, 1 pint per hundred birds, may be fed thoroughly mixed in a moist mash.

Sour or hanging crop may be treated by flushing out the crop with a bicarbonate of soda solution consisting of 2 teaspoons of the soda to a pint of warm water, in a fountain syringe. Hold the head of the bird down, and empty the crop by gentle pressure, repeating the process daily until the bird recovers. Keep the bird on a soft diet, principally sour milk or buttermilk, for several days after recovery takes place. Following attacks of indigestion it is sometimes beneficial to stimulate the appetite and promote the secretion of digestive fluids by the administration of a tonic. A veterinarian can best prescribe the tonic most suitable in a particular case.

DISEASES OF THE REPRODUCTIVE ORGANS

INFLAMMATION OF THE EGG DUCT (SALPINGITIS)

Inflammation of the egg duct is characterized by a whitish diarrhea and a creamy discharge from the egg duct which soil the feathers around the vent and cause redness and irritation of the skin. Other birds attack the affected individual, severely lacerating the posterior parts and in a short time disemboweling the victim.

The sporadic occurrence of bloody eggs, stinking eggs, misshapen eggs, yolkless eggs, eggs with blood-smeared shells, soft-shelled eggs, egg-bound, etc., may at times be traceable to isolated cases of salpingitis and may even be the forerunner of a general outbreak of the disease. Some outbreaks of salpingitis are traceable to infection with *Salmonella pullorum*. Many cases of peritonitis caused by the internal rupture of infected egg yolks may be variations of this disease.

Treatment.—When only a few birds are affected, relief may be afforded by douching the egg duct with a one-half of 1-percent solution of creolin. Segregating the visibly affected birds, thus protecting them from attack by others, should increase the number of recoveries. Male birds should be kept away, as they may spread the infection to healthy hens through breeding activity. This condition often occurs, however, even in virgin pullets, without reference to the activities of the male, and differs in this respect from vent gleet.

In outbreaks of salpingitis which may be traced to *Salmonella pullorum* infection it would be unwise to use for breeding purposes any birds which had been affected, as to do so may cause the spread of pullorum disease in the chicks.

EGG-BOUND

The condition known as egg-bound (failure to pass the egg in the normal manner) is of frequent occurrence in fowls, especially in pullets beginning to lay.

Cause.—The difficulty may be due to inflammation, stricture, or tumor formation in the posterior part of the egg passage. Sometimes malformed or double-yolked eggs are responsible. In pullets the usual cause is the attempted passage of a large-sized egg before the egg passage has become sufficiently dilated to accommodate it.

Symptoms.—Affected hens become restless and make frequent visits to the nest in their effort to lay. The straining may cause inflammation and often eversion of the oviduct (egg tube) through the vent. Others of the flock, attracted by the inflamed, protruding parts, peck at them and tear out portions of the egg passage and intestine, causing the death of the hen. If prolapse does not occur, the distressed fowl may continue her efforts to lay until successful or until overcome by weakness or internal hemorrhage from rupture of the oviduct. The egg may be felt by passing the forefinger through the vent.

Treatment.—The surest method of treatment is to remove the egg by the following procedure: Pass the forefinger through the vent. With the other hand pressing on the abdomen of the fowl force the egg toward the vent, guiding it by the aid of the inserted finger. When the shell is observed through the vent, puncture it with an awl or other sharp-pointed instrument, break it in pieces, and withdraw these and the egg contents. Isolate the bird and inject cold water into the cloaca (the common passage into which the intestine and the oviduct open) to reduce the inflammation. If the oviduct has been everted through the vent, clean and push the parts back and inject cold water frequently until the tissues remain in place.

VENT GLEET (CLOACITIS)

Vent gleet is an infectious, venereal disease of fowls which is spread by the rooster in treading. Its causative agent is not known.

Symptoms.—There is inflammation of the cloaca and vent. The skin around the vent is swollen, reddened, and ulcerated, and an offensive odor is usually present. The droppings are foul smelling and liquid, and are frequently voided. Other chickens may peck at the inflamed part and often tear the cloaca and rectum, causing the death of the victim.

Treatment.—The disease is very resistant to treatment. It is usually better to destroy the bird. If treatment is desired, 3-percent silver nitrate solution may be applied to the mucous membranes of the cloaca by means of a cotton swab, or 2-percent carbolic ointment may be applied daily over the affected area.

MISCELLANEOUS DISEASES AND CONDITIONS

TUMORS

A number of varieties of tumors occur frequently in birds. The largest percentage is found in fowls more than 2 years old. In hens the egg organs are affected in more than 50 percent of the cases. Tumors in birds have a marked tendency to break down and cause death from internal hemorrhage. Tumors on the skin are easily recognized while internal ones may be suspected when an individual in the flock shows poor condition, increasing droopiness, or emaciation.

Treatment.—There is no treatment for internal tumors. External ones can be removed satisfactorily in some cases by surgical means. Since many of the growths, however, are of a malignant or cancerous nature, it is best to kill the bird and destroy the carcass.

LAMENESS IN GEESE AND DUCKS

Young geese and ducks are affected with an inflammatory condition of the joints of the feet and wings associated with an internal infectious disease.

Cause.—The disease is caused by a micro-organism known as *Staphylococcus aureus*, which multiplies in the internal organs and in the bones and joints.

Symptoms.—The disease may be acute, causing death in from 2 to 4 days, or chronic, with symptoms continuing for more than 2 weeks, when death may occur or gradual recovery take place. In acute cases there is general depression, diarrhea, and discharge from the eyes. In chronic cases the general symptoms are less marked, but emaciation is pronounced. The characteristic symptoms in both cases are lameness and the swelling of the joints of the legs or feet. Usually only one leg will show lameness, and the hock joint or one of the toe joints is most often affected. The swellings are hot and painful. The bird frequently lies on its breast with legs extended backward and, if forced, can move only short distances by flapping the wings. Sometimes the wing joints are swollen and the wings droop.

Post-mortem appearance.—The intestine is inflamed and its contents are slimy and reddish in color. The liver and spleen are enlarged. The diseased joints are reddened, swollen with fluid, and contain yellowish, fibrous, or cheesy exudates.

Treatment.—Acute cases do not respond favorably to treatment. The joints should be painted daily with tincture of iodine. Separate the sick from the well and keep the houses and utensils clean and disinfected. Keep the ducks and geese from stagnant water, and when giving drinking water dissolve one-third of a teaspoon of permanganate of potash in each gallon to prevent contamination of the water.

WING LAMENESS IN PIGEONS

Pigeons have swollen and disabled wing joints as a result of tuberculosis, gout, or mechanical injuries. They also are affected with a disease which is caused by an infectious organism resembling somewhat the causative agent of tuberculosis. This germ grows underneath the skin and induces the formation, on the head, neck, or wings, of lumps of yellowish, cheesy material which enlarge to the size of a marble. When these lumps are present in the wing, especially near a joint, flight may be impaired or made impossible.

Treatment.—Lance the skin over the growth, press out the ball of cheesy matter, and paint the cavity with tincture of iodine daily for several days.

BUMBLEFOOT

Bumblefoot is a term applied to a swelling of the foot in fowls. It may result from bruises or from cuts or punctures of the skin of the foot, which becomes infected by germs. The invading organisms set up an inflammation with the formation of fluid or cheesy, suppurative material, in the ball of the foot, in the spaces between the toes, or in both locations (fig. 10). Recent investigations have shown that in many cases of bumblefoot an organism is present which resembles that of fowl tuberculosis.

Treatment.—In some cases the application of tincture of iodine to the swollen area daily for several days will bring about recovery. If the swelling is hot and has the appearance of an abscess, it should be lanced and the contents washed out. The interior of the abscess is then soaked with 5-percent carbolic acid or tincture of iodine and the foot bandaged. The fowl should be placed in a small compartment without a perch and the wound disinfected daily for several days.

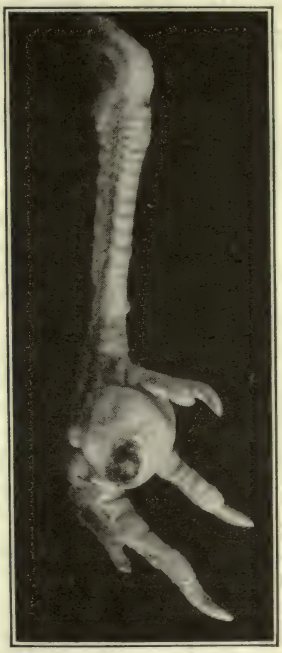

FIGURE 10.—A typical case of bumblefoot in a chicken.

SUBCUTANEOUS EMPHYSEMA (AIR UNDER THE SKIN)

Subcutaneous emphysema is a condition in which the skin of the breast and other parts of the body is distended by air, and thus separated from the underlying tissues of the bird's body. This gives the bird a peculiar puffed-up appearance. The inflated condition of the skin is immediately detected by handling the bird. Chickens, pigeons, and turkeys are susceptible to the condition.

Cause.—It is probable that subcutaneous emphysema is ordinarily caused by a rupture of one of the air sacs of the body, or other respiratory organs, which permits a leakage of inhaled air into the spaces immediately beneath the skin.

Treatment.—No medicinal treatment for the condition is known. Relief may be afforded by slitting the skin over affected areas, thus allowing the accumulated air to escape. Some cases may be reduced by exerting prolonged gentle pressure over the distended portions of the body of the bird, and in this way forcing some of the air out through the same avenue by which it gained entrance into the subcutaneous region.

FEATHER PULLING

Feather pulling is a vice which may originate from several causes, such as close confinement, idleness, lack of sufficient mineral or animal matter in the feed, or the presence of itch mites at the base of the feathers. (See Depluming Scabies.) A particularly vicious hen may begin the practice, which may be imitated by others of the flock and continued as a habit.

Treatment.—Allow as much room as possible for exercise. Scratching for feed in deep litter helps to keep the birds busy. Provide a variety of feeds with meat scrap and plenty of green feed and crushed oystershell. The early discovery and isolation of the principal offenders will frequently check the trouble where it is merely a habit and not due to other causes. If mites are present, treat as for depluming scabies.

Feather pulling and cannibalism may be prevented by cutting off the tip of the upper beak about three-sixteenths of an inch from the point.

CANNIBALISM

Toe pecking is observed in young chicks, especially those confined in brooders. Chicks peck at feed stuck to the foot and thus wound the skin. The taste of blood causes them to continue pecking at the toes of the victim and to attack other chicks. They may also peck at the vent and disembowel the chick in a short time.

Treatment.—Remove all wounded chicks as soon as they are observed and isolate them until recovery is complete. Keep the others occupied by hanging vegetables or bones with shreds of meat attached at a height which will cause them to jump in reaching them. It may be advisable to confine the flock in a partially darkened place for a while. Painting the windows with transparent red paint, or providing illumination solely through red electric bulbs to disguise the color of blood, has been found to aid in checking cannibalism among either young or adult birds.

LIMBER NECK (BOTULISM)

The condition known as limber neck is a symptom of several diseases, among which are botulism or other food poisoning. It is characterized by a paralysis of the muscles of the neck, which makes it impossible for the bird to raise its head from the ground. This condition is due to the absorption from the crop or intestines of poisons which act on the nervous system and cause paralysis. It is generally associated with the eating of spoiled feed or putrid meat in which certain poison-producing organisms are growing, or of fly maggots which have bred on such material.

Treatment.—The best treatment is to give a full dose of purgative medicine—that is, one-half teaspoonful of Epsom salts, or three or four teaspoonfuls of castor oil for a grown fowl. Unless treatment can be given very promptly there is little hope of saving the bird. Spoiled canned goods should not be fed to chickens. Carcasses of fowls or other animals should be burned or deeply buried as soon as found.

ROSE-CHAFER POISONING

Rose chafers, or rose beetles, are extremely poisonous to chickens under 10 weeks old. They are found in the Atlantic Coast, Middle West, and Central States. When these beetles are on vegetation chickens devour them readily, and only a few are necessary to cause death.

Symptoms.—Signs of poisoning may appear as early as 1 hour after feeding on the chafers, and death may follow in 1 hour after the appearance of symptoms. If sufficient poison is not absorbed to cause death, the bird recovers. The affected chicken becomes drowsy, shows weakness of the legs, and falls over on its side. There may be convulsions. Sharp cries are frequently emitted, and the head and neck are retracted over the back of the bird. The only evidence of the disease is the presence of rose chafers in the crop.

Treatment.—The rapid action of the poison renders treatment futile in birds showing symptoms. When the nature of the trouble is realized, other birds in the flock which had opportunity to eat chafers should be given Epsom salts in the proportion of one-fourth of a teaspoonful, mixed with a small quantity of feed, to each bird. Preventive measures consist in keeping young chickens in enclosed runs or at points where they will not have access to grapevines, rosebushes, and shrubbery when the insects are prevalent. This corresponds somewhat closely to the time of first blossoming of the various garden flowers. Destruction of the beetles should be practiced by spraying infected plants with one-half to three-fifths of a pound of lead arsenate to 10 gallons of water.

SALT POISONING

Chickens, turkeys, and pigeons are susceptible to poisoning by common salt. Care should be taken not to leave fish brine, freezing brine, or ice-cream salt within reach of the fowls, as they may swallow sufficient quantities of the material to poison them.

This form of poisoning is manifested by progressive paralysislike symptoms accompanied by extreme drowsiness, and finally death by asphyxiation due to the weakening effect of the poison upon the muscles of respiration. There is no practical treatment for salt poisoning of poultry.

PARASITES AND PARASITIC DISEASES

A number of different kinds of parasites found in poultry in the United States may seriously affect the health of the birds. These parasites may be divided into three general groups. One group, known as Protozoa, consists of organisms so small that they can be seen only with the aid of a microscope. The second group consists of worm parasites, of several kinds, all but a few of which are sufficiently large, when full-grown, to be seen with the naked eye. The third group is made up of small, parasitic arthropods, namely, certain insects (including lice and fleas), and certain mites, which include not only mites as commonly known but also ticks. The location of parasites varies greatly with the different kind of parasites; protozoa may occur in the blood stream, in the kidneys, and in the intestines of certain domestic birds; worm parasites may occur in such varied locations as the eye, the windpipe, all parts of the digestive tract, the reproductive organs, and in or under the skin; and arthropod parasites of poultry occur chiefly on the outside of the body, either on the feathers or in or under the skin, but, on the other hand, in the case of certain mites, may occur within the body, in the air passages, lungs, and liver.

METHOD OF EXAMINING FOWLS FOR PARASITES

An examination of a domestic bird for the purpose of determining whether parasites are present must take into consideration these differences in the kinds of parasites and their possible locations. As regards the internal parasites, for locating protozoa, smears or sections made from infected parts of the bird must be examined microscopically. On the other hand, to locate worm parasites and the mites which occur within the body, the various parts of the body may be examined according to some such procedure as the following:

In examining a dead fowl the feathers are removed from the under side, the abdomen is carefully opened along the median line, and the breast is cut loose on each side and turned forward, as in figure 11. The various internal organs are then carefully loosened from the tissues which hold them in place, and, after being spread out, as in figure 12, so that they can be separated and identified, they are removed from the bird. The windpipe or trachea (*a*) is cut open and its inner surface examined; the lungs (*k*) are also removed and carefully inspected. The esophagus, including the undilated part, and the crop (*b* and *c*), are slit open and the contents washed into a shallow glass dish and examined; the wall of the esophagus is examined by stretching it between the hands and holding it up between the observer's eyes and the light so that the light

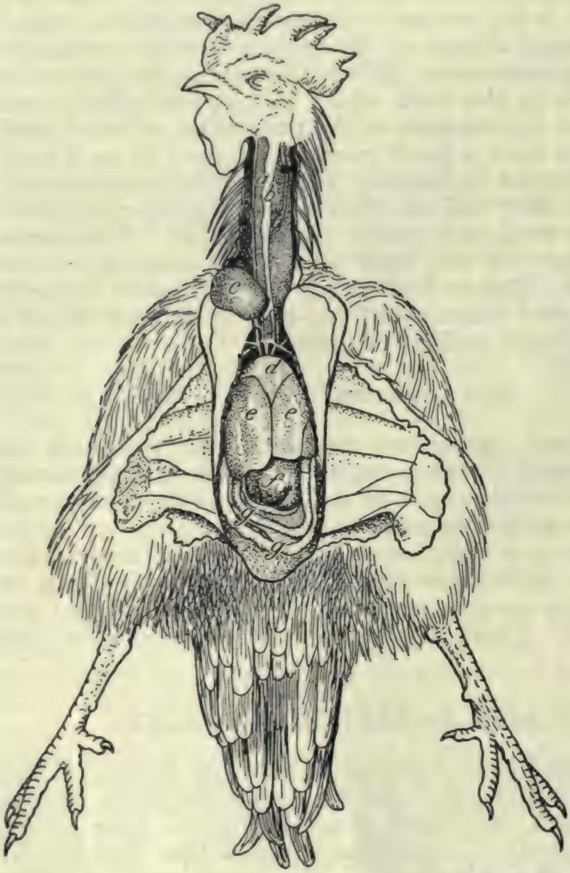

FIGURE 11.—Appearance of internal organs when fowl first is opened up. See figure 12 for explanation of letters. Adapted from Sunderville, 1928.

shines through it and thus throws into relief the outline of any worms embedded in the wall. The remainder of the digestive tract, made up of the two stomachs, namely, the glandular stomach (*h*) and the muscular stomach or gizzard (*f*), and the intestines (*g*), is next cut loose and lifted out into a dish of water. The glandular stomach or proventriculus (*h*) is opened and washed into a glass dish, and the glands are squeezed so that embedded parasites may be loosened; the wall is examined on both the inner and outer surfaces, one of the nematodes found in this location, namely, the globular, red tetramere, often showing more clearly through the semitransparent outer surface than through the opaque inner surface. The muscular stomach or gizzard (*f*) is opened, and its contents are emptied out and examined; the horny lining is then peeled off, and the under surface of the lining and also the newly exposed surface of the muscular wall are examined for parasites. The small intestine (*g*) and finally the ceca (*i*) are slit open in water, separately; the wall of these organs is run through between the thumb and fingers and examined carefully during the process, in order to remove any parasites which are buried in the mucus or attached to the wall; the intestinal contents may be washed and allowed to settle several times until the water is clear, and then examined in shallow glass dishes.

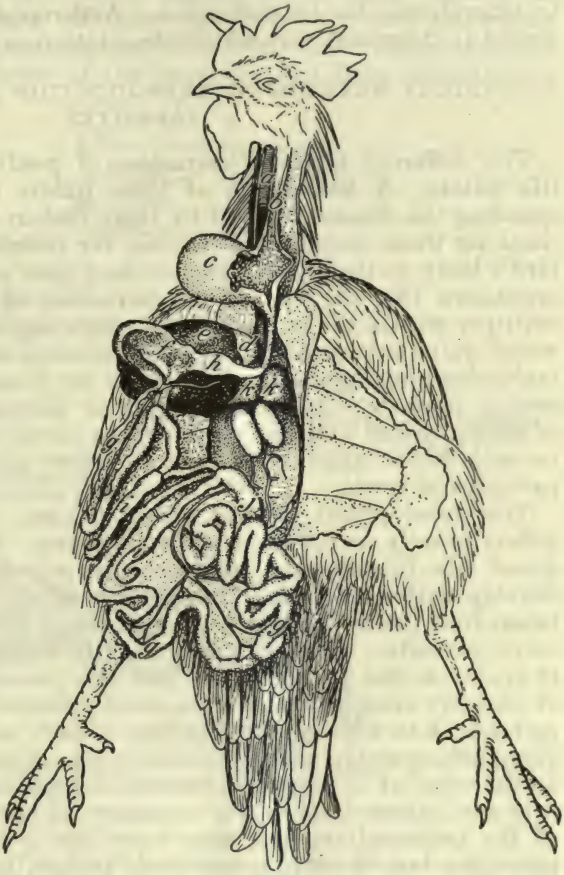

FIGURE 12.—Internal organs of fowl, which have been spread out; *a*, Windpipe or trachea; *b*, undilated esophagus; *c*, crop; *d*, heart; *e*, liver; *f*, gizzard; *g*, intestines; *h*, glandular stomach; *i*, ceca or blind guts; *j*, rectum; *k*, lungs. Adapted from Sunderville, 1928.

METHOD OF KILLING AND PRESERVING PARASITES

Protozoa can be found to best advantage in fresh material, and certain organisms belonging to this group can be found only in such material. Other protozoa, as the coccidia, if microscopical examination cannot be made of the intestinal contents when fresh, are recognizable on examination if the material is preserved by the addition of formaldehyde solution. Worm parasites which have been collected should be washed well in water in order to remove all mucus or other clinging material, and should then be put into a weak solution of formaldehyde (from 2 to 4 percent), which has been warmed to the point at which it begins to steam. Material of this sort can be shipped to laboratories for identification. Arthropod parasites may be preserved in 2-percent formaldehyde solution or 75-percent alcohol.

VARIOUS METHODS OF REPRODUCTION AND OF SPREAD OF PARASITES

The different kinds of parasites of poultry have very different life habits. A knowledge of these habits is important in understanding the diseases caused by them and in deciding on methods of checking those diseases. Protozoa, for instance, multiply within the bird's body so that one organism may give rise to large numbers of organisms (fig. 16, *A*). Worm parasites, on the other hand, do not multiply within the bird's body; a single egg or single young parasite which gains entrance into the body develops into only one worm, and multiplication depends on the eggs or young worms produced by such a parasite; the parasite eggs or young worms must pass out of the body and undergo more or less development on the ground or in such lower animals as insects before giving rise to additional parasites in birds.

The development of the various stages outside the bird's body differs greatly in different worm parasites. In some cases there is a direct life history; the parasite eggs which pass out of the body develop within them the young stage of the worm, which on being taken into the body of a bird will infect it and will develop to an adult parasite. In other cases the life history is indirect; the bird is known as the primary host, and the parasite eggs which pass out of its body must go into one or more intermediate hosts before again going back to a bird. An example of such an indirect life history is given subsequently with reference to one of the flukes found in birds. In the cases of indirect life histories of tapeworms and roundworms, only one intermediate host is necessary, so far as is known; the nature of the intermediate host may vary and is still unknown for some parasites, but in certain instances insects, snails, slugs, and earthworms have been found to serve in this capacity. Figure 13 gives in diagrammatic form the various steps in such a life history.

GENERAL MEASURES FOR THE CONTROL OF PARASITES OF POULTRY

Poultry houses and yards should be so placed that rain water will not wash from one to another. Marshy places should be drained, and holes in which water may collect should be filled in. Even if permanent quarters must be used to some extent, a rotation of yards is highly desirable; the ground should be plowed under and then planted to green stuff when the yard is not in use.

As the most severe damage from parasites occurs in young birds, special precautions should be taken to protect the young. They should be raised away from the older birds, which are often carriers of parasites, and from the infected areas occupied by older birds.

As regards sanitation, feed and water should be given in containers which will not allow contamination of the contents with the birds' droppings. The frequent removal and disposal of droppings are likewise important preventive measures. Disposal should be effected by a method which will keep the droppings with their content of worm eggs and protozoa not only from the chickens but also from the intermediate hosts of the parasites and from wild-animal life which may serve as carriers in one way or another. It is advisable to keep yards free from boards and miscellaneous objects, since they may harbor such intermediate hosts or carriers. Filling in or draining low, damp areas which may breed such intermediate hosts, and the screening of houses are also of value in this connection. A screen, to be effective, should have a mesh small enough to keep out even such small insects as the smaller dung beetles.

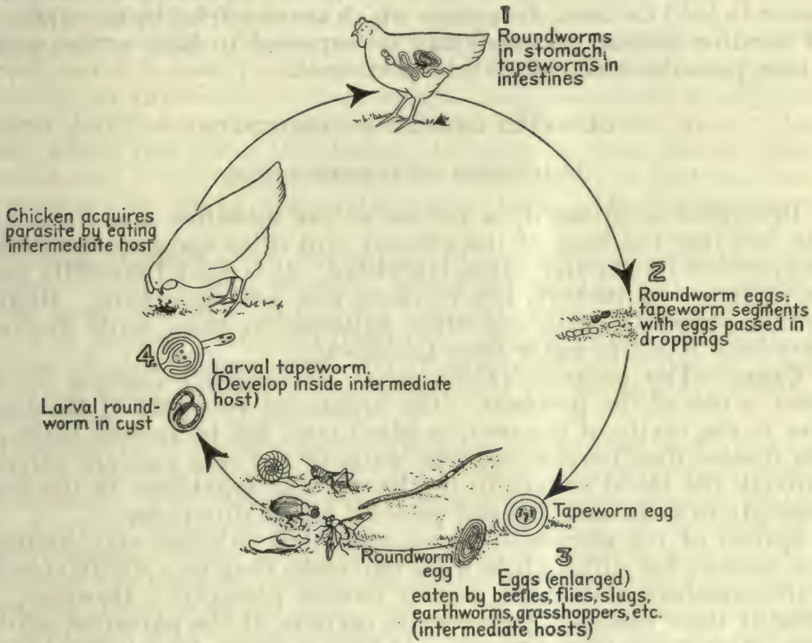
1
Roundworms in stomach; tapeworms in intestines
2
Roundworm eggs; tapeworm segments with eggs passed in droppings
Tapeworm egg
3
Eggs (enlarged) eaten by beetles, flies, slugs, earthworms, grasshoppers, etc. (intermediate hosts)
Roundworm egg
Larval round-worm in cyst
4
Larval tapeworm. (Develop inside intermediate host)
Chicken acquires parasite by eating intermediate host

FIGURE 13.—Diagram of the various stages in an indirect life history of a tapeworm and a roundworm, parasite in poultry.

The practice of using chicken manure as fertilizer is dangerous from a poultry standpoint, if the manure is spread in places where chickens will have access to it or in places where small animal forms may feed on it and may serve as intermediate hosts or as mechanical carriers to convey parasites back to the poultry. The danger is lessened if the chicken manure is stored in a manner that causes it to heat. The development of heat in the chicken droppings during storage tends to destroy worm eggs and other harmful organisms. Lack of oxygen also aids in this destruction.

A method of storage for horse manure which produces sufficient heat to destroy worm eggs has been worked out by the Bureau of Animal Industry and used with very satisfactory results; this method would probably be applicable to poultry manure. A double-walled, double-floored, wooden box, with sawdust between the double parts of the walls and floor for insulation, and with a tight cover to hold the heat, was found to be the best kind of storage; all parasitic-worm eggs were destroyed in a period of 2 weeks in horse manure stored in this manner. It is a common practice to store chicken droppings in barrels. If the barrels have tight covers and suitable external insulation to hold the heat, droppings which are not dried by the addition of sand or similar material may be expected to heat to the point where parasitic material will be destroyed.

DISEASES CAUSED BY PROTOZOA

BLACKHEAD (ENTEROHEPATITIS)

Blackhead is primarily a disease of the intestines and liver, but the fact that the head of the affected bird often becomes discolored has given it its popular name, blackhead. It is most frequently seen as a disease in turkeys, but chickens also are susceptible. Ruffed grouse, bobwhite quail, and other gallinaceous game birds likewise have been found to suffer from the disease.

Cause.—The parasite (*Histomonas meleagridis*) causing blackhead is one of the protozoa. The organisms live part of the time free in the cavity of the ceca, or blind guts, but in another stage of the disease they burrow into the walls of the ceca and are carried through the blood stream to the liver. The organisms in the ceca multiply in large numbers and pass out in the droppings.

Spread of the disease.—Young and adult chickens may contract this disease, but although in some outbreaks they may die in considerable numbers, they more usually recover promptly. However, in spite of their recovery, they remain carriers of the parasites, which are discharged in their droppings in vast numbers, from 20,000,000 to 40,000,000 of the organisms passing daily from one chicken. These organisms may infect other birds, either chickens or turkeys, if picked up by them in contaminated feed or water. The realization that turkeys may die, in large numbers, of blackhead contracted from chickens which have the disease in so mild a form as to show no evidence of it has led to strong emphasis being placed on the recommendation that turkeys be kept away from chickens.

It is probable that the parasite which causes blackhead was originally brought to North America in chickens from Europe and that it was passed on to turkeys in this country, thus introducing a new disease to which turkeys were more susceptible than were chickens, which in the course of time had become resistant to it.

Another highly important factor in the spread of the blackhead disease is the part played by the common cecum worm (*Heterakis gallinae*) of chickens and turkeys. The worms in the ceca of a fowl which is infected with the blackhead organisms may carry these organisms in their bodies; the eggs of the worm, which are passed out in large numbers in the droppings of the fowl, carry these small blackhead parasites with them. When the eggs are eaten, in contaminated feed or water, by a fowl and hatch in the fowl's ceca, the blackhead organisms are transmitted to the bird and set up the disease. The protozoan parasite, being thus included within the shell of the worm egg, is protected from heat, cold, dryness, and other adverse conditions which would otherwise destroy it. The worm eggs, which are resistant to such factors because of their thick shells, can hold the blackhead organisms in the soil from one year to another, whereas it has been found that the blackhead organism itself, without such protection, seldom survives for more than 24 hours outside the body of the fowl.

Symptoms.—The disease may occur at any time in the life of a turkey, but it is most prevalent in young birds. Droopiness, loss of appetite, an invariable loss of weight, and sometimes a sulphur-colored diarrhea are the main symptoms. The discoloration of the head, which has given the disease its name, is seen also in other diseases and is not always present in this disease, so that the term "blackhead" is not a very satisfactory term. Death may occur suddenly.

Internal changes.—An examination of the turkey after death shows the ceca, or blind guts, enlarged and filled with a solid, yellowish, cheesy mass; the walls of the ceca may have areas which are roughened and thickened. In addition to the changes in the ceca, the liver is often affected; it is enlarged and often spotted with dark-red, gray, or yellow areas, which are depressed below the surface rather than raised above it (fig. 14).

Treatment.—Although many drugs have been tried and some are recommended for the treatment of blackhead, none have been found satisfactory. The only practical, general procedure consists in the use of control measures to prevent the development of the disease.

Prevention.—Since, as explained above, the chicken may act as a carrier of the parasite causing blackhead disease, turkeys should be kept completely removed from chickens or land ranged by chickens or fertilized with chicken manure. In addition the best results are obtained with artificially reared birds—that is, those hatched in incubators and brooded artificially. The poults should be kept first in coops and runs that can be easily cleaned, and later on pasture that is known not to have been ranged by chickens and preferably not to have been used for older turkeys. The University of California has found losses among such artificially reared turkeys to be much less than among those reared under the old system. At the North Dakota Agricultural College blackhead was prevented by placing poults, when 6 to 8 weeks old, on a rearing ground, fenced and cross-fenced to provide 4 runs, for monthly rotation; houses and fences are portable and are moved yearly for a 5-year rotation system.

Since cecum worms spread the blackhead parasite, the University of Nevada Extension Service suggests that the tobacco-dust treatment for removal of these worms should begin when the turkeys are 3 to 4 weeks old. Mash containing 2 percent powdered tobacco is fed for 2 days, followed on the third day by Epsom salts, 1 pound in 5 gallons of water or milk; the treatment is repeated once each month until the birds are 5 months old. After each treatment, removal of the turkeys to clean quarters is necessary to prevent reinfection. Losses from blackhead have been considerably reduced in this way. Other treatments for cecum worms are given in this bulletin (p. 59). Any turkeys which show symptoms of the disease should be promptly removed and isolated, and those which have died should be buried.

COCCIDIOSIS

Cause and nature of the disease.—For many years it was thought that minute protozoan organisms known as coccidia, found in a large variety of birds, both domestic and wild, were all the same species, *Eimeria avium*. Recent studies, however, have revealed that there are at least six species of coccidia in chickens alone, the diseases caused by them varying in location and intensity. One species, *E. mitis*, ordinarily produces no noticeable damage to the intestinal wall and does not seriously affect the health or growth of the chicken; at other times it is distinctly injurious. Another species, *E. tenella*, which is found in the blind guts, or ceca, of the chicken, affects the health of the bird very decidedly, producing the symptoms of coccidiosis as they are most widely known among poultry raisers. This is the acute form which is often seen in baby chicks during the first few weeks of life; the coccidia invade the wall of the gut and often produce extensive hemorrhages, blood being noticeable in the droppings. Other symptoms, which in fact may appear earlier than the bloody droppings, are ruffled feathers, pallor, and rapid wasting (fig. 15). Chicks up to 2 months of age may die very suddenly and in large numbers as a result of this form of the disease.

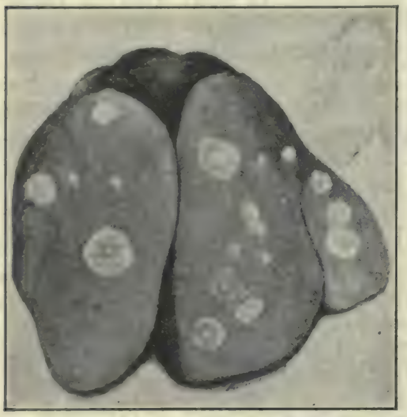

FIGURE 14.—Enterohepatitis (blackhead) Liver of turkey, showing necrotic areas.

A serious chronic form of coccidiosis may be caused by another species, *E. accervulina;* the organisms in this case live chiefly in the upper part of the small intestine, producing whitish or grayish spots in the wall. Extreme emaciation or wasting of the fowls in severe cases is the principal characteristic of this form of coccidiosis.

Another coccidium, *E. maxima*, occurs in the middle or lower part of the small intestine, producing a thickening of the wall with a variable amount of hemorrhage; however, the quantity of blood passed in the droppings is never so great in this disease as in that involving the ceca. In severe cases of this type, pallor, roughening of the feathers, and diminished appetite result.

E. praecox and *E. necatrix* occur in the small intestine. The latter is pathogenic and produces severe hemorrhage.

Turkeys may be infected with coccidia, *E. meleagridis* and *E. meleagrimitis*, species different from those found in chickens. Although outbreaks of coccidiosis occasionally occur in young turkeys, the disease is not yet so widespread or so severe in these birds as it is among chickens. It is probable that the young poults develop an immunity to the organisms at an early date, as turkey poults may show the presence of these coccidia within the first week after hatching, but may not appear to be injured by them.

Pigeons are also parasitized by one of the coccidia, *Eimeria labbeana;* the disease produced may be rapidly fatal or may be chronic. In geese, coccidia produce a disease of the kidneys which may weaken them so greatly that they are unable to walk; the birds become progressively weaker until they die. Ducks may suffer severely from an intestinal form of coccidiosis. There is evidence that a species of coccidium is usually limited to one kind of bird.

Method of contracting the disease.—In all forms of coccidiosis, the disease is spread by contamination of the feed, water, and soil with the droppings of fowls which harbor the parasites. The coccidia pass through certain stages of development in the outside world (fig. 16, *B* and *C*); later, when taken into the body of a bird in the act of eating or drinking, the organism continues its development, multiplying in large numbers (fig. 16, *A*).

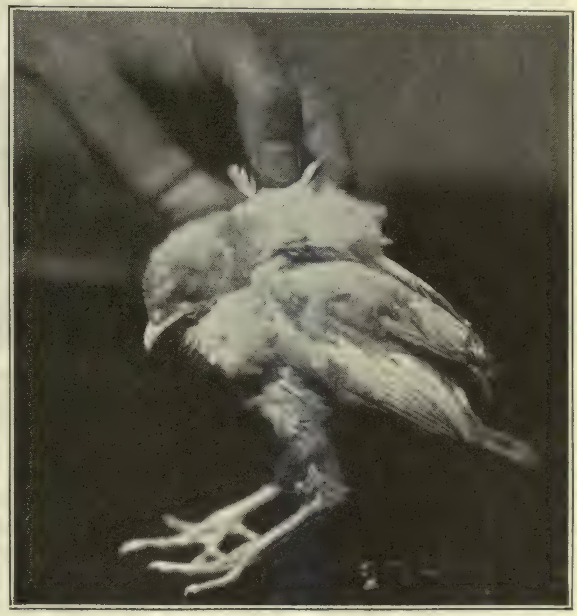

FIGURE 15.—Chick suffering from coccidiosis; cecal form.

As regards the transmission of coccidia to young birds through the egg, it appears never to have been demonstrated that the organisms may be included in the egg at the time it is formed. Even if such transmission were possible, it is improbable that it would happen frequently; it is much more likely that the organisms would be on the outside of the egg, the contamination of the eggshell occurring as the egg was passing out of the cloaca and vent. However, critical investigations have shown that coccidia on the eggshell were not able to survive the incubation of the eggs. It is probable that coccidiosis is contracted by the young chicks much more frequently by other means than by transmission through or on the egg.

The organisms may be carried for considerable distances in running water or in dust, or on shoes, grain sacks, or other objects, or may be spread by birds or by flies or other insects which fly from one poultry yard to another; rats and mice also probably serve to spread the organisms. It has been found that a single organism is capable of producing a mild form of the disease, the organism multiplying in the chick's body and considerable numbers of the parasite later being passed in the droppings, so that as a result the infection is capable of spreading to the other chicks. It is apparent, therefore, that there are many ways in which a small amount of the disease-producing material may be spread.

Post-mortem findings.—If the course of the disease has been short, as sometimes happens in the acute form of coccidiosis, with death occurring early, there may be no visible changes in the intestines; microscopical examination of the intestinal contents will show the presence of coccidia in some stage of development, however. If the disease is of longer duration, changes will have taken place, the nature of which will depend on the species of coccidia present, as noted above. In the acute form of coccidiosis in which the site of infection is in the blind guts, or ceca, these organs may be enlarged and filled with blood, and in later stages the cavity of the cecum may be plugged with a thick core, a yellowish, cheesy substance with dark bloody areas in it.

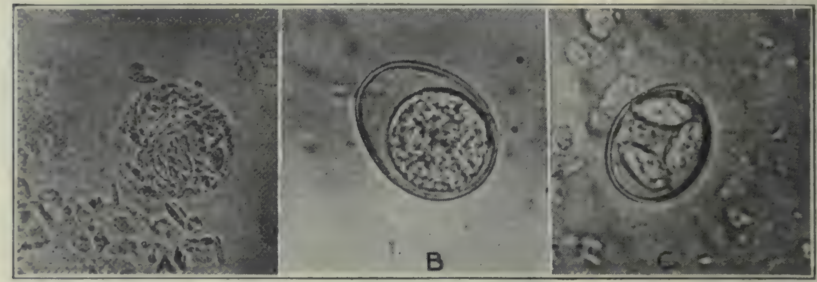

FIGURE 16.—Various stages of development of organisms which cause coccidiosis: *A*, Manner in which one organism gives rise to a large number of organisms in cecum of fowl; *B*, organism as passed in the droppings of fowl; *C*, organism which has developed to a stage which will infect the fowl. (After Johnson, 1924.)

Immunity.—There is evidence that chickens which have suffered an attack of coccidiosis are subsequently immune to the species of coccidium that was responsible for the attack but are not immune to other species. There is apparently no such immunity as age immunity, but only immunity following previous infection.

Treatment.—Many treatments have been tried and advocated for coccidiosis, but none have been satisfactory. This may be due partly at least to the fact that instead of one species of coccidium being involved, as was formerly thought, there are several.

It is the consensus of opinion among parasitologists and veterinarians that there is as yet no effective treatment for coccidiosis. Good results have been reported from the use of various chemicals, but have not had convincing confirmation. Catechu, sodium bicarbonate, potassium permanganate, copper sulphate, cresol, formaldehyde, and areca nut, in each case given by mouth, are among remedies shown to have no value in this respect. Under the circumstances, no treatment can be recommended as of established value or proved efficiency. Instead of placing reliance on medicinal treatment, efforts should be directed toward prevention, as outlined below.

Prevention.—Extensive studies of coccidiosis have brought to light two important facts: (1) That the severity of the disease depends on the number of organisms which are taken into the body of the fowl, and (2) that the disease runs a limited course. In nonfatal cases the fowls recover, and the organisms usually disappear within a month's time, unless reinfection has taken place. Control measures which take these facts into consideration are therefore indicated.

Although there has been little success in the medicinal treatment of coccidiosis after it has fully developed, measures can be taken to prevent the development of the disease in chickens and to reduce its injurious effects if it appears. Strict sanitation, as described below, will reduce the number of organisms and a well-balanced nutritious diet will help to build up the resistance of the fowls.

The feeding of a mash containing 40 percent of dried skim milk or buttermilk has been reported by the California Agricultural Experiment Station as effective in protecting young chicks from coccidial infection, the mash being fed as soon as the presence of coccidiosis is detected and continued for 1 to 2 weeks; grain is continued but the quantity reduced, and green feeds and an abundant supply of water are provided as usual. The results of the use of such increased quantities of milk, however, have not been entirely consistent; in some cases it has failed to check the disease and has even appeared to produce injurious effects, such as pronounced diarrhea, with more or less prostration. The addition of egg rather than milk to the diet has been recommended as fulfilling the need of a tempting, nutritious diet for the chicks.

Daily cleaning is highly advisable, in order that the organisms which are being passed in the droppings may be prevented from developing to the stage which is infective. As a disinfectant for houses and yards, a 2- to 4-percent solution of liquor cresolis compositus or other coal-tar creosotes used in strong, hot solutions may be helpful; recent experimental studies indicate that spraying the litter with a mixture of coal-tar acids in a light mineral oil may also be of value. As the coccidia, however, are very difficult to destroy, cleanliness and the frequent removal of droppings containing the infectious material are highly important, and disinfectants must be regarded only as aids in connection with cleaning up. Coccidia need moisture for their development; hence thorough drying checks this development. They are susceptible to high temperatures also, boiling water destroying them quickly and hot water of somewhat lower temperature more slowly (a temperature of approximately 130° F. kills them in about 30 minutes). Practical measures based on these principles include: (1) Burning over the ground or runs; (2) the application of a layer of slaked lime to the ground; (3) putting feeding troughs and drinking vessels into boiling water at frequent intervals; (4) burning carcasses of fowls which have died of the disease; and (5) burning or removing to remote areas the litter or other refuse which may be contaminated with infected droppings.

Strictest precautions should be taken to prevent the contamination of feed supplies while they are being mixed and subsequently while being stored; they should be protected from flies and mice and from the dust of poultry houses or runs.

Rearing chicks on raised wire-mesh floors, through which the droppings will fall, is probably the most effective preventive measure, but birds reared in this way must be kept away from infection subsequently, as they do not have the acquired resistance of birds which have passed through an attack of coccidiosis in early life. Whatever the system of rearing, avoidance of crowding is highly important. The screening of houses and runs in order to keep flies out and thus prevent their spreading the organisms is also of value.

TRICHOMONIASIS

Chickens may occasionally suffer from another disease, known as trichomoniasis, caused by a protozoan, *Trichomonas* sp., in the ceca; this disease, however, appears to be relatively less common and less severe than those previously described. Young chicks up to a month of age may die of the infection. The mildness or severity of the disease may vary with different strains of the organisms that cause it. The feeding of sour milk is said to be of value in the treatment of this disease; flies may spread the organisms, however, so that powdered buttermilk, in the mash, is preferable to liquid milk, since the latter attracts flies.

PIGEON MALARIA

Cause.—A protozoan parasite, *Haemoproteus columbae*, which lives in the blood of pigeons, invading the red blood corpuscles, is the cause of pigeon malaria.

Spread of the disease.—Pigeon malaria is spread by the pigeon fly, *Pseudolynchia maura*, the latter being necessary for the transmission of the parasite from one bird to another. The fly in biting takes in the parasites with the blood of the bird; the parasites multiply and develop within the insect's body and are then introduced into a bird by the bite of the fly.

Symptoms.—The destruction of the red cells by the parasites may cause anemia, a condition in which the blood becomes less red, this in turn lowering the vitality of the birds. Aside from this there are no marked symptoms.

Prevention.—Prevention consists in the destruction of pigeon flies. The Bureau of Entomology and Plant Quarantine recommends a thorough cleaning of the pigeon nests at intervals not to exceed 25 days, using a light spray of kerosene extract of pyrethrum in the interior of buildings, and one of the following procedures: Dusting the squabs and pigeons with fresh pyrethrum powder, derris powder, or tobacco powder containing about 6 percent of nicotine; dipping them with either an aqueous extract of pyrethrum with soap or derris extract with soap and water; or using the kerosene extract of pyrethrum spray on the birds.

WORM PARASITES AND THE DISEASES CAUSED BY THEM

FLUKES

Flukes are small, flat worms, more or less resembling a leaf in shape. Their life histories always involve at least one intermediate host and sometimes two. There are two different kinds of flukes which have been found to cause disease in poultry in the United States and, although they are as yet rare in occurrence, they should be kept in mind as of possible importance in the future.

FLUKES CAUSING INJURY TO THE EGG-FORMING ORGANS

Parasite and the damage produced by it.—One species, *Prosthogonimus macrorchis*, reddish in color and about a quarter of an inch long, occurs in chickens in Michigan, Wisconsin, and Minnesota. Such flukes usually occur in the cloacal region, but they may invade the egg ducts and ovaries, causing serious injury to those organs. The symptoms shown by the fowls are dullness, loss of weight, and pallor; egg production is greatly decreased. In Europe, closely related parasites cause serious losses among chickens, ducks, and geese. The fluke occurs always near lakes or marshy places, such an environment being essential in its life history. It may occur in eggs laid by infected hens.

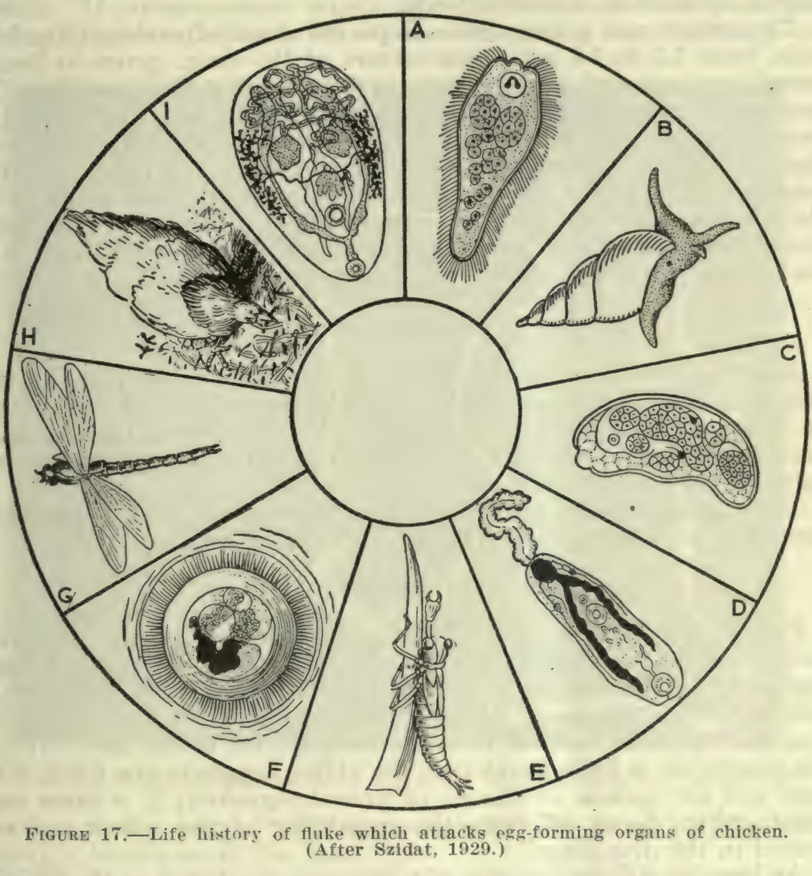

FIGURE 17.—Life history of fluke which attacks egg-forming organs of chicken. (After Szidat, 1929.)

Life history of parasite.—The life history of this parasite involves snails and also dragonflies, as shown in figure 17. The young worm (*A*), which hatches from the fluke egg, develops partially in the snail (*B*) to a form of different appearance (*C*); then, leaving the snail as a tailed form (*D*), it swims around and is drawn into the body of the young stage of the dragonfly, which lives in the water during its early life (*E*); in the insect the parasite forms a cyst (*F*); and, when the young or adult dragonfly (*G*) is eaten by the chicken (*H*) the worm develops to its adult form (*I*), from which the fluke eggs pass and begin the cycle again.

The parasite has been found in wild ducks and has been produced experimentally in crows and English sparrows; it probably may be spread by them to domestic fowls.

Treatment and prevention.—Repeated doses of carbon tetrachloride, from 1.5 to 1.7 cubic centimeters of the drug, given in liquid cereal, are reported as a successful treatment for this parasite. To prevent chickens from becoming infected in an area in which the parasite occurs, the fowls should be prevented from eating dragonflies. Chickens probably capture the flies when the latter are still cold and inert in the early morning, and keeping fowls confined to their houses until the air has warmed would probably help to keep down infection. Otherwise, fowls should be fenced away from lake shores and other wet places.

The Cystic Fluke in the Skin

Another fluke, *Collyriclum faba*, has been found in cysts in the skin of chickens and turkeys in considerable numbers in Minnesota. In addition to injuring the general health of the fowl, the parasites produce blisters in the skin, the disfigurement reducing the market value of the fowl.

The parasite occurs also in the English sparrow and is probably spread by that bird. The life history is unknown.

TAPEWORMS

Description of parasite.—Tapeworms, or cestodes, are flattened worms made up of numerous divisions or segments, following a head region by which the tapeworm is attached to the intestinal wall. The tapeworm grows at the neck region, just behind the head, so that the segments farthest from the head are the oldest ones. When the tapeworm is fully developed, the oldest segments are filled with eggs and are spoken of as ripe or gravid segments; it is these segments which break off from the remainder of the worm and are passed in the droppings.

At least 10 different species of tapeworms are found in the United States in chickens, 9 or possibly 10 in turkeys, and several other species in the other domestic birds, such as ducks, geese, pigeons, and guinea fowls. The tapeworms vary much in size (fig. 18), some being so small that they are seen or found only with difficulty, whereas others are several inches in length.

Method of spread of tapeworms.—The life histories of tapeworms of poultry, so far as they have been definitely ascertained, indicate that these tapeworms must pass part of their lives in an intermediate host. This host is some small form of animal life which is eaten by poultry, either accidentally with feed or water, or actually as one of the items of feed. In the case of some of the tapeworms of poultry the nature of the intermediate host is as yet unknown, but in other cases it has been definitely ascertained that dung beetles, ground beetles, ants, the housefly, snails, slugs, and earthworms serve as hosts for various chicken tapeworms; grasshoppers serve as hosts for one of the turkey tapeworms.

Damage done by tapeworms.—One of the larger tapeworms, *Raillietina echinobothrida*, found in chickens produces in the intestine, especially in the lowest third of its length, numerous protuberances or nodules, which closely resemble the nodules caused by tuberculosis. If tapeworms are attached by the head to the inner surface of the intestine at the site of the nodule, such a condition may be ascribed to the worms. If tuberculosis is also present, there will probably be lesions in the liver.

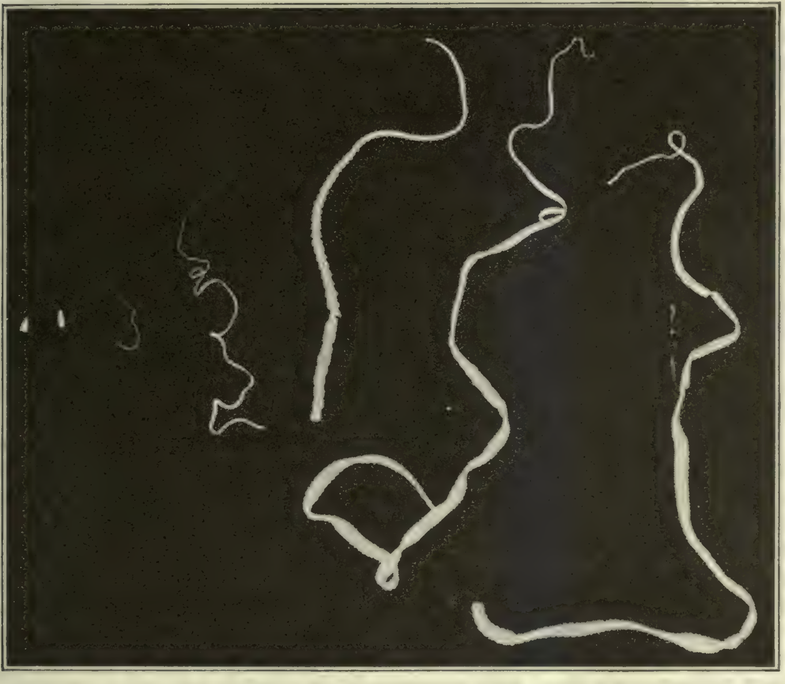

FIGURE 18.—Seven different species of tapeworms found in chickens. Natural size.

In the case of other tapeworms, however, the injury to the intestinal wall is not so marked. Loss of weight, loss of appetite, a general condition of droopiness or unthriftiness, intestinal catarrh, and diarrhea are the conditions most frequently found associated with the presence of tapeworms. Young fowls are most seriously affected. Occasionally, lameness and paralysis have been associated with heavy infestations with certain tapeworms. If these conditions are caused by tapeworms, the removal of the worms will clear up the condition, but the same conditions may be caused by other things, and the finding of tapeworms associated with these conditions does not prove that there is a connection between them.

Treatment.—There is no satisfactory drug for the removal of poultry tapeworms. Experiments carried out some years ago in the Bureau of Animal Industry and at the University of Wisconsin indicated that kamala was an effective drug for use against poultry tapeworms, but a large amount of subsequent research has shown that kamala usually exerts only a "shearing" effect, removing the tapeworm strobilae or chains of segments but leaving practically all (more than 99 percent) of the many tapeworm heads. These heads produce new chains of segments, and tapeworm-egg production is renewed in 2 or 3 weeks.

The difficulty in removing heads of poultry tapeworms appears to be purely mechanical. The heads burrow deeply, reaching points deep in the mucous lining of the intestines or beyond this to the muscular layer or even to the serous coat on the outside of the intestine. No drug has yet been shown to be capable of reaching and killing these deeply buried heads. The only visible damage done by these tapeworms is that caused by the heads setting up inflammation and killing the surrounding tissues to which they are attached.

It has never been shown that the chains of segments in the cavity of the intestines do any damage or that they abstract any food of which the chicken could or would make use; consequently, there is no evidence that the removal of these chains of segments by treatment, without removing the heads, does any good. There is no critical evidence showing that such treatments are of value, and there is some evidence of bad effects on egg production, for instance, following the treatment. Under the circumstances, no treatment can be recommended until research develops a means of reaching and killing the heads of poultry tapeworms.

Prevention.—To prevent the spread of tapeworm disease, the droppings of the fowls should be disposed of in such a way that the known intermediate hosts of the parasite, such as beetles, ants, flies, slugs, snails, and earthworms, are kept from eating the eggs or segments of tapeworms passed in the droppings of infested fowls; and poultry should be prevented from eating these intermediate hosts which may be carrying larval stages of tapeworms. Prompt removal of droppings, keeping the yards and houses free of trash, boards, boxes, and other unnecessary objects, and the filling in or liming of damp places near feed and water vessels, which places may serve as hiding or breeding places for the intermediate hosts, are valuable preventive measures. The plowing up of pens and seeding them to short growing vegetation, rather than leaving them in a weedy, fallow condition, helps to reduce the number of ground beetles.

In some places poultrymen have resorted to raising chickens in confinement, under screen, and on raised floors, in order to prevent their becoming infested with tapeworms. Certain of the beetles, however, which are known to serve as intermediate hosts are considerably smaller even than house flies, so that the mesh of the screening must be fine enough to keep out such small insects, to be thoroughly satisfactory.

In order that poultry droppings may not be wasted but may be used for manure, without danger of spreading worm infection, it is recommended that the droppings be stored for a while, as previously described.

ROUNDWORMS

Eye Worm of Poultry

The parasite *Oxyspirura mansoni*, known as Manson's eye worm, is known to have been present in Florida for many years and has recently spread to Louisiana. It occurs in chickens, turkeys, and peafowls, and can develop in various wild birds. The parasite is found under the nictitating membrane, that is, the transparent membrane which passes over the eyeball of the fowl in the act of winking. The worms are slender and colorless and are about three-fourths of an inch long; they can often be detected by a firm pressing of the tear sac at the inner corner of the eye, when they will wiggle out over the eyeball.

Symptoms and damage produced by parasite.—Affected fowls wink the eye continuously and frequently attempt to rub the head on the feathers of the wing, or to scratch at the eye with the foot. The eyesight is not good. There is puffiness around the eye and a discharge from the eye and from the opening of the nostril. There is often a severe inflammation which may result in blindness; at times the entire eyeball is destroyed.

Life history of parasite.—This roundworm has an indirect life history, and its intermediate host has been shown by workers of the Florida Agricultural Experiment Station and elsewhere to be a cockroach, *Pycnoscelus surinamensis.* The cockroaches are found beneath boards and trash and in the vegetation at the edges of the fences; they feed on whatever food material is present, including the droppings of the fowls. From the droppings the cockroaches obtain the eggs or newly hatched larvae of the roundworms, the eggs having been washed down the tear ducts from the eye of the fowl and having then been swallowed and passed in the droppings. The young roundworm develops in the body of the cockroach and when the roach is eaten by a fowl the worm is freed in the bird's crop. It passes up the esophagus to the mouth and then through the tear ducts to the eye.

The cockroach which spreads the parasite in this manner in Florida and Louisiana also occurs in Texas, and in certain places in the North it has been found in greenhouses. There is danger, therefore, that the eye worm may spread to States other than Florida and Louisiana. By the feeding of cockroaches containing the young stages of the worms, the eyeworm has been experimentally developed in ducks, bobolinks, a blackbird, a pigeon, a loggerhead shrike, and a blue jay; such birds as these must, therefore, be considered possible carriers of the roundworm in areas in which it is found in poultry.

Prevention.—The removal from the chicken yard and houses and from the area around the yards, of all trash, boards, boxes, and other unnecessary objects, which may serve as hiding places of cockroaches, is probably the most important control measure. Roaches which come from the outside into a clean yard, free from objects which may serve as hiding places for them, are likely to be eaten promptly by the chickens before the roaches have a chance to become infected by eating the chicken droppings. Such uninfected roaches will not cause worm infestation. Hiding places enable the roaches to become infested and to infect the chicken which subsequently captures them. The daily collection of droppings and their removal to a place where cockroaches cannot get at them is a measure of value. Affected birds should either be treated and cured or killed and destroyed.

Treatment.—The Florida Agricultural Experiment Station recommends the following as the most effective treatment: Drop into the eye of the fowl a 5-percent solution of butyn as an anaesthetic; then lifting the nictitating membrane of the eye, place one or two drops of a 5-percent solution of creolin directly on the worms. Immediately after applying the creolin, wash it out well with water; the worms will have been promptly killed by it.

GAPEWORM OF CHICKENS AND TURKEYS

A roundworm which produces unmistakable symptoms of disease is the gapeworm, *Syngamus trachea.* This parasite occurs in turkeys and chickens but with a decided difference in effects. As a rule, the gapeworm will live in chickens only when the chickens are very young, the first few weeks of life being the danger period. The chicks that live through the acute stage of gapeworm disease soon lose the worms, and, therefore, do not remain carriers. On the other hand, adult as well as young turkeys commonly harbor gapeworms and usually show no bad effects, and it is apparently the infested turkey that is the chief cause of the spread of gapes to chicks. Young turkey poults suffer from gapes only rarely, and it is very unusual to find gapeworms in a mature chicken.

Gapeworms are attached to the wall of the windpipe or trachea, on its inner surface (fig. 19). The male and female worms are joined together so that the two worms form a Y.

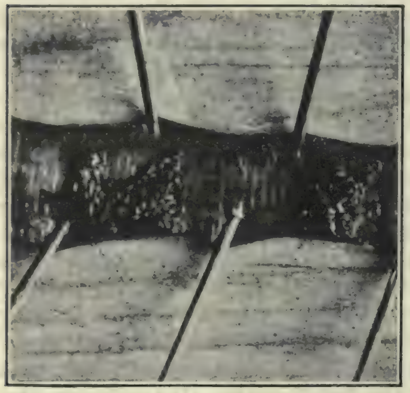

FIGURE 19.—Gapeworms in windpipe of chick. (After Hall, 1916.)

Symptoms and damage produced by parasite.—The worms clog the windpipe of chicks, and because of an insufficient supply of air young chicks which have gapeworms in the windpipe will open the beak and gape; this behavior has given rise to the name "gapes", as applied to the disease. There is often a convulsive shaking of the head, with a hissing cough. This continuous effort to obtain air prevents the chicks from feeding; this and also the fact that the worms are bloodsuckers weaken the chickens so that they become thin and pale. Death may result from suffocation or from general weakness.

Life history of the parasite.—This parasite has a direct life history. Eggs of the parasite are coughed up from the windpipe and swallowed by the chicken or turkey which harbors the worms. These eggs pass out in the droppings, develop, and some of them hatch. Either the infective eggs or the young roundworms which hatch from them may then be swallowed by fowls in the act of feeding or drinking. Within a week the young worms will have reached the lungs, and from there they work their way up into the windpipe and may be fully developed within another week or 10 days.

Earthworms may play an important part in the spread of gapes. The infective eggs or the young gapeworms which have hatched in the soil from the eggs in the fowls' droppings may be eaten by earthworms; they burrow into the body muscles of the earthworm and may remain alive for considerable periods. The earthworm in these cases is not a necessary intermediate host of the parasite; it is merely a mechanical carrier or reservoir, protecting the young gapeworms from conditions such as drought and high and low temperatures, conditions which would otherwise kill the young parasites. Earthworms may thus carry the young gapeworms over from one warm season to another.

Another important factor in the spread of gapes is the fact that turkeys may carry gapeworms throughout their whole life and thus may spread them to young chickens, if turkeys and chickens are being raised together.

Prevention.—Raising young chicks entirely separate from turkeys and areas ranged by turkeys is the most important preventive measure. If gapeworm disease has been present in the vicinity, dry, sandy soil should be selected for young chicks to run on, since such soil is unfavorable to earthworms; or young chickens should be shut up until the dew has dried off in the morning, when most of the earthworms which have come to the surface will have disappeared.

Treatment.—No treatment has been found to be thoroughly satisfactory. Mechanical removal, although a slow, difficult, and rather dangerous procedure, may be accomplished by the insertion of a loop of horsehair down the windpipe and the rotation of the loop in such manner as to dislodge the worms from the wall and entangle them in the hair, which is then withdrawn. A small quill feather, which is stripped of all its web except a small tuft at the end, may also be used in place of the hair; a little kerosene or oil of turpentine put on the feather will aid in loosening the worms and later will cause the chick to sneeze or cough and thus help to bring up the worms. Wire extractors made by commercial firms are used in the same manner.

Various medicinal treatments have been advocated, but none can be regarded as of proved value.

Crop Worms

Roundworms may occur in the crop and occasionally also in the undilated esophagus of chickens and turkeys. They are sewed into the walls and have the appearance of a wavy, white thread. The worms move around inside the wall and form burrows or tunnels.

One of these roundworms, *Gongylonema ingluvicola*, is comparatively rare, and is not known to injure the health of the fowl aside from slight local damage to the wall of the crop. This roundworm has an indirect life history; there is evidence that cockroaches and dung beetles may be the intermediate hosts.

Another crop worm, *Capillaria annulata*, has been found more recently in this country, but appears to be of much more common occurrence. In severe cases these roundworms may be present in large numbers and may greatly damage the walls of the crop and the undilated esophagus (fig. 20). They interfere with digestion, and the fowls become progressively weaker and finally may die from the effects of the parasite. Recent evidence indicates that earthworms serve as the intermediate host of this crop worm. On the other hand, in the case of a closely related species, *C. contorta*, which occurs in domestic ducks in Europe and in turkeys, gallinaceous game birds, and wild ducks in the United States, direct experimental transmission from one bird to another has been accomplished. The eggs which pass out in the droppings develop to a stage which will infect the fowl swallowing them in contaminated feed or water.

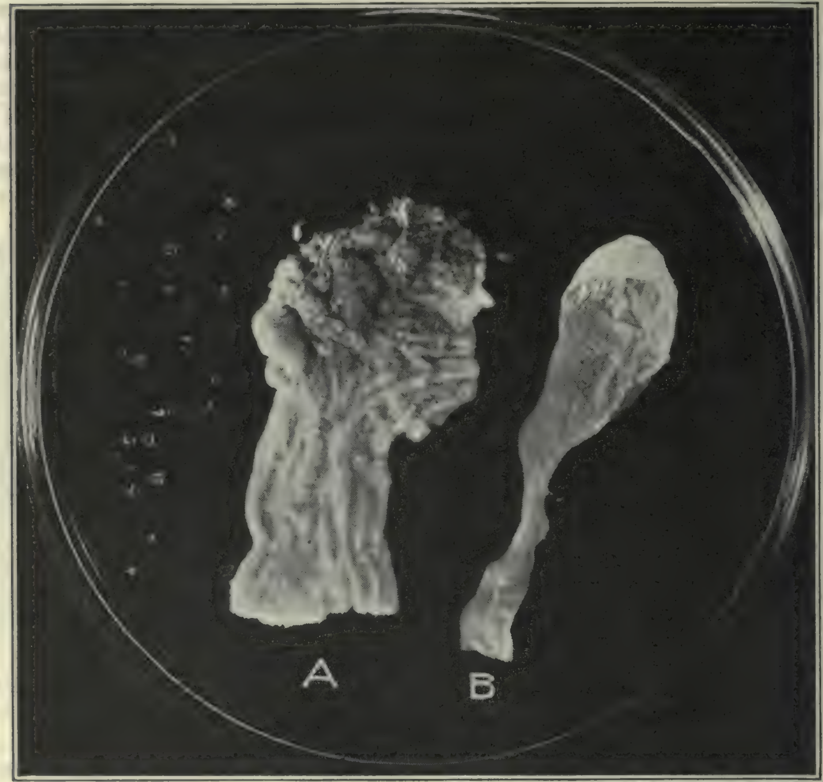

FIGURE 20.—*A*, A crop heavily parasitized by the crop worm, *Capillaria annulata*; *B*, a normal crop. Note on the extreme left, the threadlike worms which caused the injury.

Prevention of crop worms.—General sanitary measures such as described on page 38 are advised.

Treatment.—The feeding of soft, highly nutritious feeds in place of grain is of value in overcoming the effects of crop worms. No medicinal treatment has yet been developed. Worms which have burrowed into the crop are more or less protected from the action of drugs. Carbon tetrachloride or tetrachlorethylene in fairly large doses (from 2 to 5 cubic centimeters), given when the crop is empty, may be of value if the damage to the wall of the crop has not been too severe. (See p. 58 for administration of these drugs.)

STOMACH WORMS

In the two stomachs of domestic birds, that is, in the proventriculus or glandular stomach and in the gizzard or muscular stomach, several different kinds of roundworms may be found.

THE TETRAMERE OF CHICKENS

The parasite, *Tetrameres americana*, shows very striking differences from most other roundworms. The usual slender, elongated form of roundworms is lost in the case of the female tetramere (fig. 21). While young, these parasites enter the glands of the stomach and as they develop to adults the large number of eggs which form within the body causes it to swell until it is practically globular in shape; also, its color changes to bright red. These parasites may be present in adult fowls without any apparent injury to the health of the fowl. In young chicks, however, they interfere with the proper digestion of food, so that general weakness and diarrhea, and even death, may result.

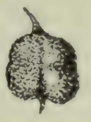

FIGURE 21.—A tetramere from the glandular stomach of a chicken. Enlarged about four times.

Life history.—The tetramere has an indirect life history and the intermediate hosts have been found to be grasshoppers and cockroaches.

Prevention—Raising young chicks in such a way that they cannot feed on grasshoppers or cockroaches which may have had access to the droppings of older, infected chickens, and disposing of droppings so that the worm eggs in them are destroyed or that insects cannot get at the droppings, are the most important preventive measures.

Treatment.—A soft, highly nutritious feed, rich in vitamins, has been found to help chicks to overcome the bad effects of this parasite. No medicinal treatment is known; that suggested above for crop worms may be of value in this connection.

THE SPIRAL STOMACH WORM

A short, white roundworm, *Dispharynx spiralis*, which is curved or even twisted in a spiral, is found occasionally in the glandular stomachs of chickens, turkeys, and pigeons, as well as in gallinaceous game birds, in this country, and if present in considerable numbers may seriously affect the health of the bird. The more evident symptoms are droopiness and loss of weight, in spite of the fact that the birds have a ravenous appetite even up to the time of death. In pigeons the eye has been said to lose its color when the birds are suffering from the effects of this stomach worm. The stomach may be considerably enlarged and the glands of its walls may be partly or almost completely destroyed.

Life history.—This roundworm has an indirect life history, and sow bugs, or pill bugs, have been found to be the intermediate hosts.

Prevention.—Measures which will eradicate sow bugs from the premises, so that the birds cannot eat them, are of great importance. Keeping the birds in dry, light quarters and the removal of unnecessary objects under which the sow bugs may hide are of value in this connection. The proper disposal of droppings, either to destroy worm eggs or keep them from all intermediate hosts, is important.

Treatment.—No satisfactory treatment is known, although that suggested previously in the case of the tetramere, and also in the case of crop worms, may be of value.

GIZZARD WORM OF CHICKENS AND TURKEYS

A slender, white, gizzard worm, *Cheilospirura hamulosa*, about one-half to three-fourths of an inch long, has been the cause of deaths of chickens in this country, and has also been found in turkeys. It passes through the horny lining of the gizzard, leaving small, round holes with raw, raised edges (fig. 22), and burrows into the muscular wall, producing tunnels in the wall or causing the formation of wartlike growths on its surface. Eggs of the parasite pass out of the holes and mix with the gizzard contents, eventually being discharged by the bird in its droppings. The wall of the gizzard may be so badly damaged by these worms that the digestion of food is interfered with and the health of the fowl consequently suffers from it.

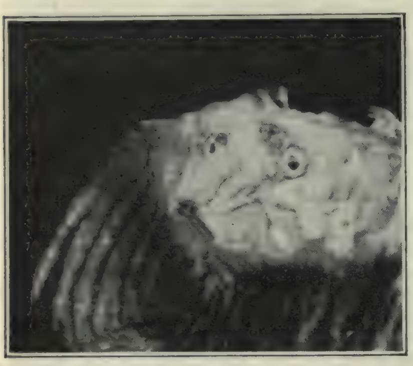
FIGURE 22.—Holes made by gizzard worm in the horny lining of gizzard of chicken.

Life history.—This roundworm has an indirect life history and its intermediate hosts have been found to be grasshoppers.

Prevention.—Sanitary measures, such as frequent collection and proper disposal of droppings so that grasshoppers may not feed on them and thus become infected with the early stages of the roundworm, and secondly, measures to prevent the fowls from eating grasshoppers, are advised. Confining fowls to runs which have been sown to a short, thick, green vegetation, such as grass, rather than allowing them to range in long, dry vegetation which is favorable to grasshoppers, helps to reduce the number of these insects eaten by the fowls.

Treatment.—Unknown; that suggested for the tetramere and for crop worms may be of value in this connection.

GIZZARD WORM OF DOMESTIC GEESE AND DUCKS

In domestic geese and ducks a small, slender roundworm, *Amidostomum anseris*, sometimes reddish in color from blood which it has swallowed, may be found burrowing in the horny lining of the gizzard; it does not invade the wall to so great an extent as does the gizzard worm of chickens and turkeys but causes more damage to the surface. There is considerable loss of blood by the bird, and the gizzard lining shows roughened areas stained brown from blood. The parasite may produce poisons which also weaken the bird. Numerous deaths may occur in flocks in which these parasites are present in large numbers.

Life history.—This roundworm has a direct life history. The eggs pass out in the droppings, young roundworms hatch from them, and, after being taken in by the birds in the act of eating or drinking, the worms develop to adults in the gizzard. This parasite has been transmitted experimentally from the domestic goose to the domestic duck in this manner.

Prevention.—Sanitary measures which prevent the contamination of feed and water with the droppings of infected fowls are of value.

Treatment.—This parasite has been successfully removed from young geese by administering to each bird a 1.5 to 2 cubic centimeter dose of carbon tetrachloride, given in about 8 cubic centimeters (about two teaspoons) of liquid cereal.

INTESTINAL ROUNDWORMS

LARGE ROUNDWORM OF THE INTESTINE

The large roundworm or ascarid, *Ascaridia galli*, found commonly in chickens and less commonly in domestic ducks, geese, and turkeys, occurs in the small intestine and attains a length of from 1 to 4½ inches when fully grown (fig. 23). These worms may be present in such numbers as to block the intestines. Large numbers of the young worms may kill chicks in from 10 to 12 days. The parasites stunt the growth of the chick and prevent proper bone development, so that weakness results (fig. 24). Young chicks are most seriously affected by this roundworm. If the chick does not become infected until after it is 3 months old, the parasites do less damage to it. Grown fowls which harbor this parasite may be unthrifty and their egg production low.

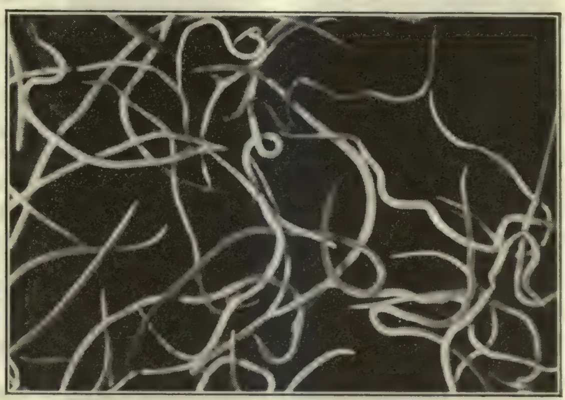

FIGURE 23.—Roundworms (*Ascaridia galli*) from the small intestine of a chicken. (Courtesy J. E. Ackert.)

The adult worms occasionally wander up the oviduct and are trapped in the hen's egg as it forms.

Life history.—The life history of this parasite is direct. The eggs of the parasite pass out into the soil in the droppings of the fowl, and the young stage of the worm develops within them in a period of about 15 to 20 days under favorable conditions. The young worm hatches from the egg when the latter is swallowed by a fowl. The young worms may burrow into the inner surface of the wall of the intestine, causing damage to the glands, for a period extending from about the tenth to the twentieth day after the egg is swallowed. Then the worms return to the interior of the intestine to develop into adults in about 2 months.

The eggs of the parasite are thick-shelled; they are resistant to cold but more easily killed by heat. In Kansas, the high temperature of summer has been found to kill all the eggs of this parasite on the surface of the soil and to a depth of 6 inches in unshaded places, but in shaded spots the eggs survived.

Prevention.—General sanitary measures should be adopted to prevent the worm eggs from developing in the soil and later being swallowed by the fowls. Rotation of runs has been found valuable. Special protection of chicks until they are 3 months of age, by raising them away from older chickens or areas ranged by such chickens, will prevent the greatest injury. A nutritious diet, rich in vitamins, has been found to be helpful in building up the resistance of the chick to this parasite.

Treatment.—The quickest and most effective treatment for the removal of the large roundworm consists in the individual dosing of each bird with carbon tetrachloride or the closely related drug, tetrachlorethylene, using a 1-cubic centimeter dose for adult birds; for young chickens, however, the dose must be reduced and given with caution. From evidence available, it is safe to treat young chickens at 2 months of age with tetrachlorethylene, which is the safer of the two drugs. The drug is most easily given in gelatin capsules, although it may be introduced directly into the crop through a soft rubber tube passed down the esophagus. Care must be taken that the drug does not get into the lungs, as in that case it may be quickly fatal.

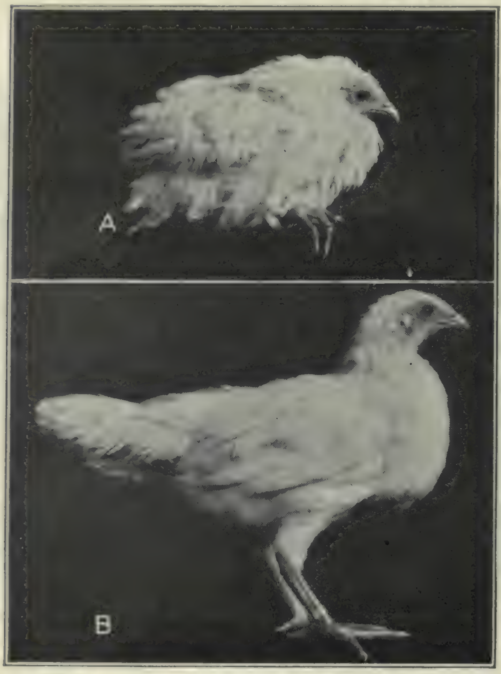

FIGURE 24.—*A*, Chicken suffering from large roundworms of the intestines, unable to recover from parasitism; *B*, control from same hatch, aged nearly 4 months. (After Ackert and Herrick.)

Another individual treatment consists in the administration, to each bird, of a no. 2 capsule containing 0.35 gram of a mixture of 6.6 cubic centimeters of 40-percent nicotine sulphate and 16 grams of Lloyd's alkaloidal reagent, which is a selected fuller's earth.

For mass treatment rather than individual treatment the California Agricultural Experiment Station recommends the following:

> Add to the mash 2 percent by weight of tobacco dust containing at least 1.5 percent of nicotine, and feed this mixture to the flock for a period of 3 or 4 weeks. Treatment may be repeated at 3-week intervals as often as necessary

If a single-dose treatment is desired for the removal of the large roundworm, the California station recommends the use of one teaspoon of oil of chenopodium, thoroughly mixed with a moist mash, for each lot of 12 birds.

LARGE ROUNDWORM OF PIGEONS

In the intestines of pigeons may be found a large roundworm which closely resembles that found in chickens, but it is a different species, *Ascaridia columbae.* This parasite may be present in large numbers, as many as 500 having been collected from 1 pigeon. The worms are sometimes found to have wandered into the stomachs and even up into the esophagus. The life history is probably similar to that of the large roundworm of chickens, and preventive measures would be similar in the two cases, with modifications to meet the different conditions under which pigeons are raised.

Treatment.—Carbon tetrachloride in repeated doses of from 1 to 2 cubic centimeters, given in liquid cereal or in liquid paraffin, has been satisfactory for the removal of this parasite. The pigeons may occasionally regurgitate the drug.

COMMON CECUM WORM, OR HETERAKID, OF POULTRY

The common cecum worm of poultry is also known as the heterakid, *Heterakis gallinae;* it occurs in the ceca, or blind guts, of chickens, turkeys, guinea fowls, and domestic ducks and geese. This worm attains a length of from three-tenths to one-half inch. The worms are sometimes present in enormous numbers and may cause a serious inflammation of the ceca, especially in young chicks. As already noted, they are apparently involved in the transmission of blackhead in the presence of infective blackhead material.

Life history.—The life history of this roundworm is direct, the eggs developing in the soil in a period of from 7 to 12 days under favorable conditions. They are very resistant to freezing and to drying. The young worm hatches from the egg when it is swallowed by a fowl. The young worms invade the wall of the ceca for a short period, and may do considerable damage at this stage; later they return to the interior of the ceca and develop to adults in about 24 days after entering the fowl's body.

Earthworms may be a factor in spreading cecum worms and other worms; the eggs of the roundworms may be eaten by the earthworms and later reach fowls by being passed in the casts of the earthworms and thus infecting otherwise uninfected soil, or by the earthworms being eaten by the fowls.

Prevention.—As in the case of the large roundworm, general sanitary measures, rotation of yards, and special protection of young chicks are of value in preventing infestations with this parasite.

Treatment.—The tobacco-dust treatment for the large roundworm will remove about 80 percent of the common cecum worms, if continued for a month.

An individual treatment, which will remove about 90 percent of the worms, consists in the use of rectal injections of oil of chenopodium in a bland oil, such as cottonseed oil. The dose is 0.1 cubic centimeter of oil of chenopodium in 5 cubic centimeters of cottonseed oil for a bird weighing 1½ pounds. Probably double this dose would be effective for a bird weighing 3 pounds or more. This mixture may be made up at the rate of 1 teaspoon of oil of chenopodium in 6 fluid ounces of cottonseed oil and given at the rate of one-third of an ounce to birds weighing 3 pounds or more, a proportionately smaller dose being used for smaller birds. The two ingredients should be thoroughly mixed and given with a hard-rubber enema syringe. It is as easy to give this treatment by rectum as it is to give a treatment by mouth. The tip of the syringe should be inserted into the rectum and the mixture injected slowly.

Single doses of drugs by mouth are relatively ineffective. The drugs commonly fail to enter the ceca, and the occasional entry is too uncertain to make these treatments reliable.

OTHER ROUNDWORMS OF THE INTESTINES

There are several different species of hairworms, or capillarids, *Capillaria* spp., which occur in the small intestine and ceca of domestic poultry, all kinds of domestic birds being known to harbor such worms at times. The worms are very slender and colorless, usually from one-half to three-fourths of an inch long, and are found with difficulty unless present in large numbers. They may seriously affect the health of the fowls. Carbon tetrachloride given in a 1 cubic centimeter dose, and repeated about 7 days later, has been effective in removing some kinds of capillarids. The life history, so far as known, is direct, and general sanitary measures should be adopted to prevent reinfestation.

In pigeons a serious disease may be caused by a delicate, slender roundworm the pigeon strongyle, *Ornithostrongylus quadriradiatus*, which occurs in the small intestine. The worms are blood suckers, and loss of blood by the bird is probably responsible for the severity of the effects of this disease. A treatment which has been reported as effective in expelling these worms consists in giving each pigeon 5 centigrams of thymol, three doses being given on alternate days and followed by a capsule of castor oil.

In chickens an extremely small roundworm, the chicken strongyloides, *Strongyloides avium*, has been found in the ceca; in young chicks especially, it may seriously affect the health. The walls of the ceca may be greatly thickened, and a bloody diarrhea may be present. If the chicks survive this acute stage, they may show no bad effects from the parasite, even though it is present, when the chickens are fully grown. The life history of this parasite is direct, but, unlike the direct life histories of other roundworms of poultry, this one includes stages in which the worms develop in the soil to adult males and females, which give rise to young. No treatment has yet been developed for removing this parasite. Special protection of young chicks and general sanitary measures are of value in preventing the spread of the parasite.

LICE

There are at least seven different species of lice occurring on domestic chickens, while still other forms occur on turkeys, ducks, and guinea fowls. As different species of lice are usually confined to different parts of the body and feathers, they are commonly referred to as head lice, wing lice, body lice, shaft lice, and fluff lice, although the distinction is not very exact, since the various species intermingle to some extent.

LICE ON CHICKENS

The two most important lice on chickens are the head louse, *Lipeurus heterographus*, and the body louse, *Menopon biseriatum.* The head louse (fig. 25) is most injurious to young chicks. It occurs on the head at the base of the feathers or the down; it passes readily from one chicken to another, and from the hen to her chicks. It is important to treat the hen for lice before the hatch comes off. Treatment, as given below, should be applied to the head. The body louse is most injurious to grown fowls but occasionally affects young chicks. It causes irritation to the skin, with at times the formation of scabs or blood clots. It is found directly on the skin, the most favored site being just below the vent, but head, neck, legs, and body may show the presence of these lice.

The shaft louse, the wing louse, and three other less common species are not so serious a menace to chickens.

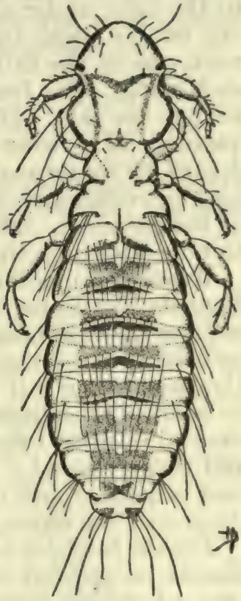

FIGURE 25.—The head louse, male, top view. Greatly enlarged.

LICE ON TURKEYS

Four species of lice are found on turkeys; two of these are species which also occur on chickens, whereas the other two are restricted to the turkey. The common body louse of chickens may cause considerable irritation to both young and grown turkeys; the shaft louse of chickens may be present, without evident bad effect. The two species which are found on turkeys only, the large louse, *Goniodes stylifer*, and the slender turkey louse, *Lipeurus polytrapezius*, may be markedly injurious to poults and may cause severe annoyance to adult birds.

LICE ON DUCKS AND GEESE

Young ducks which are hatched by hens may suffer from the head louse of chickens. There are also at least three species of lice which are restricted to ducks and geese, but they are seldom present in sufficient numbers to cause noticeable annoyance.

LICE ON PIGEONS

There are two species of lice, different from those found on other domestic birds, which cause considerable annoyance both to old birds and to partially feathered squabs.

LICE POWDERS AND THEIR APPLICATION

Experiments conducted by the Bureau of Entomology and Plant Quarantine have shown that a very satisfactory way of eliminating lice from poultry is to treat each fowl separately with sodium fluoride. If applied to all fowls as directed, one treatment is sufficient to kill all lice and their eggs. Commercial sodium fluoride may be purchased at most drug stores at from 30 to 60 cents a pound and may be applied either by the so-called pinch method or by means of a duster made by punching small nail holes in the bottom of a can having a tight-fitting cover, or by dipping. If the pinch method is used, the bird is held on a table while sodium fluoride is applied next to the skin under the feathers, as follows: One pinch on the head, one on the neck, two on the back, one on the breast, one below the vent, one on the tail, one on each thigh, and one on the under side of each wing. The feathers should be ruffled to allow the powder to get next to the skin. If the bird is held in a large shallow pan, the small quantity of powder which falls off will be saved. If the powder is dusted on by means of a shaker the quantity of sodium fluoride used may be reduced by using three parts of road dust or flour to one part of the chemical. This method requires the services of a second person to hold and turn the fowl.

When considerable numbers of birds are to be treated the sodium fluoride should be used in the form of a dip, 1 ounce of commercial sodium fluoride being used to each gallon of water. The birds should be held by the wings and plunged into a tub filled with the solution, the head being left out, while the feathers are ruffled with the hand to allow the solution to penetrate to the skin. The head is then ducked once or twice and the bird held for a few seconds to drain, and then released. Dipping is just as effective as the other methods and is quicker and more economical of material. Dipping should be done only on warm, sunny days.

To sick fowls or to very young chickens or turkeys, sodium fluoride should be applied only by the pinch method, and especially in the case of young birds it should be used cautiously, in very small pinches.

One pound of sodium fluoride will treat 100 birds by the pinch method. Figuring a person's time at 40 cents an hour and the drug at 40 cents a pound, it has been estimated that it costs about $2 to treat 100 fowls. The cost of treatment by dipping is about one-half of this amount, and the irritating effect of the powder on the operator is avoided.

Another good lice powder is flowers of sulphur, which should be applied with a duster. Although sulphur is considerably cheaper than sodium fluoride, it is less effective against lice and hence must be applied more liberally, so that its use is in reality more expensive than that of sodium fluoride. Many other powders, most of which contain pyrethrum (insect powder), are commonly used, but they have no advantage over sodium fluoride.

Dust baths containing a mixture of tobacco dust or other insecticide and ordinary road dust are often recommended to destroy lice. While it is a good plan to let the birds dust themselves when they wish, no method which allows the bird to treat itself for lice can be expected to eradicate them all, since fowls cannot get the dusting powder on all parts of the body where lice are, and many lousy birds will not use the dust baths.

A simple procedure, which is effective in controlling lice but will not eradicate them, consists in the application of undiluted 40-percent solution of nicotine sulphate to the top surface of the roosts by means of a paint brush. This is done a short time (from 15 to 20 minutes) before the fowls go to roost. The fumes of the nicotine kill the lice during the first, second, and third nights after application. The head lice, naturally, are least affected. As some of the lice are not killed and the eggs are not destroyed, it is necessary to repeat the treatment frequently.

It is possible and practicable to keep a flock of poultry absolutely free from lice and mites, and this should be the aim of everyone who is endeavoring to establish a successful poultry flock.

MITES

COMMON RED MITE

While there are many kinds of mites affecting poultry, there are three which are of special importance to poultry raisers, the best known being the common chicken mite or red mite (*Dermanyssus gallinae*). In the Northern States this mite is dormant in winter, except in chicken houses which are heated, but in the South it

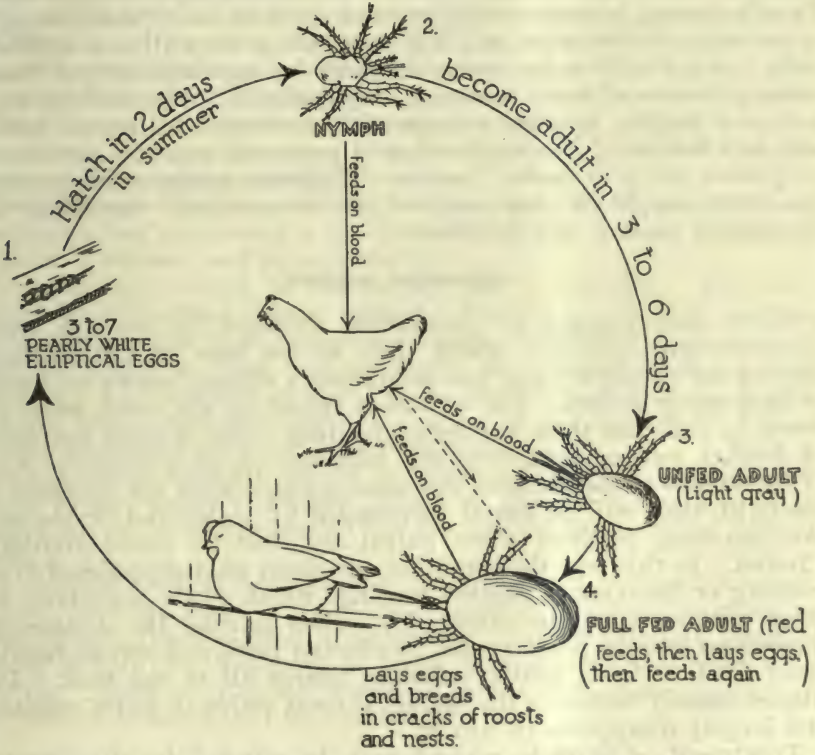

FIGURE 26.—Diagram showing the life habits of the common chicken mite.

breeds and is active the year round, although it is always most abundant in summer. Unlike the other mites affecting poultry, this parasite, with few exceptions, is found on the birds only when it is feeding (fig. 26). It is nocturnal in habits, feeding at night and hiding during the day in the cracks of the roosts, in the nests, in the corners of the floor, or between boards. For this reason its presence often remains undetected until the chicken houses are badly infested and the poultry raiser seeks an explanation for the drooping condition and listlessness of his fowls.

Treatment.—To eradicate the pest a thorough cleaning of the chicken houses and spraying with a suitable insecticide having sufficient body is all that is necessary. All roosts, loose boards, and boxes should be removed and the insecticide applied in the form of a rather coarse spray, using a suitable pump. One of the best substances for the purpose is anthracene oil. As this is a little too heavy to spray well, it may be thinned with an equal quantity of kerosene, or the undiluted material may be applied with a brush to the roosts, roost supports, nest boxes, and other places where the mites are found. High-grade creosote also gives satisfactory results. Crude petroleum is nearly as effective and is usually cheaper. It should be thinned by adding 1 part of kerosene to 4 parts of crude oil. Pure kerosene, kerosene emulsion, and carbolic acid, when brought in contact with the mites, will kill them, but as they all lack sufficient body for persistence the spraying must be repeated several times, making the use of these materials impracticable. The coal-tar dips, used in a slightly stronger solution than recommended on the labels, will be effective if the application is repeated, and the germicidal properties are a desirable feature. Whatever preparation is used, the birds should be kept out of the houses until the fluid has thoroughly soaked into the wood.

DEPLUMING SCABIES

Fowls and pigeons are sometimes infected by an itch mite, *Cnemidocoptes gallinae*, which lives at the base of the feathers, causing an intense itching and producing a disease known as mange or depluming scabies. The irritation caused by the mites leads the fowls to pull out their feathers, and they often acquire the habit of feather pulling, attacking the plumage of other birds as well. If the stumps of the feathers are examined soon after the breaking of the quill, they will be found surrounded by scales and crusts, and the adjoining feathers when pulled out will be found similarly affected. In this way the condition can easily be distinguished from molting or the vice of feather pulling, which fowls sometimes acquire without apparent cause. The mites causing the disease are introduced into the poultry yard by affected fowls and spread rapidly from fowl to fowl, finally infesting nearly all in the flock. The disease usually begins in the spring, is most active in warm weather, and largely disappears in winter.

Treatment.—Complete control may be effected by dipping the entire flock in a tub of water containing 2 ounces of flowers of sulphur and one-half ounce of laundry soap to each gallon of water. If the fowls are also infested with lice, the two pests may be eliminated with a single treatment by dipping in this mixture, to which has been added three-fourths of an ounce of commercial sodium fluoride. As the depluming mite is well protected by the skin scales, it is necessary to soak the fowls thoroughly to destroy all the mites. As a soapy mixture of this kind completely wets the plumage, special care must be taken to do the dipping on a warm day when there is little wind. When the infestation is limited to a few birds, or when for other reasons it is not desired to treat the whole flock, the trouble may be held in check by applying to the affected parts an ointment made by thoroughly mixing 1 part of flowers of sulphur with 4 parts of vaseline or lard.

THE FEATHER MITE

Infestations with the feather mite, *Liponyssus silviarum*, have occurred in many flocks during the last few years; it is very injurious in the northern part of the United States. This mite closely resembles the common chicken mite, but has very different habits in that it breeds among the feathers. The eggs are deposited and hatch among the feathers where the young mites may complete their entire development without leaving the fowl. These mites are to be found in greatest numbers below the vent, about the tail, and sometimes on the neck. The feathers often have a dirty appearance from the presence of the mites, and the skin may be irritated and scabby from the bloodsucking habits of the parasites. The feather mite may first be detected on the hens' eggs, their presence there in large numbers being said to be a characteristic sign of infestation with this mite. These mites have been found in the nests of English sparrows near infested chicken houses.

Treatment.—Feather mites may be destroyed by dipping affected fowls in a tub containing a mixture of water, 1 gallon; flowers of sulphur, 2 ounces; and soap, 1 ounce.

The feathers should be thoroughly wet to the skin. The head should be submerged for an instant. During the dipping process the mixture should be stirred so as to keep the sulphur in suspension. Dipping should be done only on warm, sunny days, or in a heated building. If treatment is found to be necessary during the winter or early spring months, thorough dusting of the fowls with flowers of sulphur should take the place of dipping.

The nesting material should be removed and burned, and nest boxes, roosts, walls, and floor should be sprayed or painted with anthracene oil as recommended for use against the common chicken mite.

A simpler method than the one just mentioned, reported as satisfactory in some cases but not so successful in others, consists in painting the perches with a 40-percent nicotine sulphate solution shortly before the fowls go to roost, and dusting the nests with sulphur. Nests of English sparrows in the immediate vicinity of the poultry house should be destroyed.

SCALY LEG; MANGE OF THE LEG

Another species of itch mite, *Cnemidocoptes mutans*, attacking chickens, turkeys, pheasants, and cage birds is the cause of a condition known as scaly leg. While this mite is usually confined to the legs, it may occasionally attack the comb and wattles. The disease occurs in most cases as a result of association with infested birds. It spreads slowly, and many individuals escape it entirely, although constantly exposed to it (fig. 27).

Symptoms.—The disease is easily recognized by the enlargement of the feet and legs and the rough appearance of the surface of the feet. The parasite begins its attack in the clefts between the toes and gradually spreads forward and upward until the whole of the foot and the shank become affected. The two legs are usually attacked about the same time and to the same degree. At first there is only a slight roughening of the surface, but the continued irritation by the mites causes the formation of a spongy or powdery substance beneath the scales, which raises them more and more until they are nearly perpendicular to the surface and are easily detached. In the most severe cases the joints become inflamed, the birds are lame and scarcely able to walk, a joint or an entire toe may be lost, and the birds, unable to scratch for feed, lose flesh and die from hunger and exhaustion.

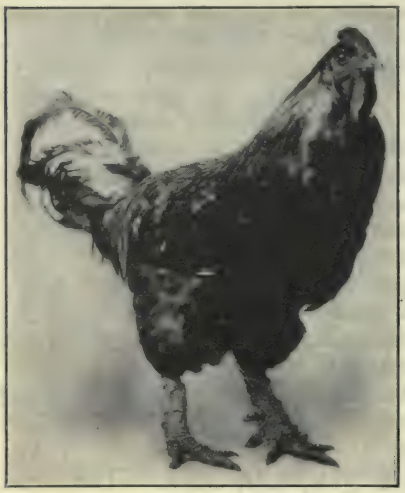

FIGURE 27.—Scaly leg.

Treatment.—The most effective treatment for scaly leg is to dip the feet and shanks of the infested birds in crude petroleum. This can be done most easily by putting the petroleum in a large bucket or tub. In dipping the feet, care should be taken not to get the oil on the upper part of the legs or on the feathers. If a large number of fowls are to be treated, it is best to do the work in the morning. This gives an opportunity for the oil to dry in and evaporate before the fowls go to roost. Another treatment which has its advocates but is more laborious is to wash the feet and legs with soap and warm water, removing all loose scales. Dry the legs and apply an ointment containing 2 percent of carbolic acid or 15 percent of fine sulphur, or a mixture of Peruvian balsam, 1 ounce, and alcohol, 3 ounces. When crude petroleum is not readily available, kerosene oil may be used as a dip for the feet. With the crude-oil treatment usually one application is sufficient, although in severe cases a second application 30 days later may be desirable. With the other remedies mentioned, a second treatment should be given 3 or 4 days after the first. To prevent the spread of the scaly-leg mites from fowl to fowl it is advisable to apply anthracene oil or crude petroleum to the roosts.

OTHER MITES

Several other species of mites infest poultry. One species bores into the skin and is found in cysts lying on the under surface of the skin next to the muscles. This form is not known to do any serious injury. Still another species occurs in the air passages, liver, and lungs of chickens. Unless present in sufficient numbers to interfere with breathing, it is not a serious pest. Still other mites live among the feathers of the birds, sometimes causing an unsightly appearance of the feathers, but apparently cause little injury to the birds themselves.

CHIGGERS, OR HARVEST MITES

Chiggers, harvest mites, or "red bugs", which so frequently annoy campers by the intense itching they produce, may also attack fowls. Young chickens having a free range, especially if it includes low-lying lands, are the most likely to suffer from these parasites. The mites attach to the skin, causing an intense itching, and abscesses may be found where clusters of mites are feeding. These abscesses are sometimes a third of an inch in diameter, surrounded by an area of inflammation. The birds become droopy, refuse to eat, and may die from hunger and exhaustion.

Treatment.—If an abscess has not yet formed, the inflamed area may be treated with sulphur ointment, Peruvian balsam, or a mixture of one part of kerosene with three parts of lard. If suppuration has occurred the scab should be removed and the area washed with 4-percent carbolic acid solution. Frequent light dusting with flowers of sulphur will keep the chickens from becoming infested. In the Southern and Central States, where harvest mites are most numerous, it is often necessary to keep young chickens off the range in summer. In these sections it is a good plan to hatch the chickens early in spring, so that when the warm weather comes, in which the mites are most abundant, the birds will be old enough to resist their attacks.

TICKS[5]

In some parts of the South poultry are commonly infested with a species of tick known as the chicken tick or blue bug, *Argas miniatus*. This parasite when full-grown may be from one-fifth to one-fourth of an inch long and is a powerful blood sucker. In its adult stage of development it has feeding habits similar to the much smaller red mite, in that it feeds only at night and spends the days hiding in cracks in the roosts or walls. Pigeons are occasionally attacked by a similar tick, and both species have been known to inflict painful bites on persons coming in contact with infested birds. These ticks, on account of their relatively large size as compared with mites, can do a great deal of damage in a poultry or pigeon house, and young birds attacked by them are liable to succumb from loss of blood. Moreover, in the case of the chicken tick, it is known that in some countries this parasite may itself be parasitized by minute organisms which are injected into the blood of the fowl which it attacks, causing a severe and usually fatal fever. In this way the tick acts as a carrier of the disease organism much as the mosquito by its bites carries the organism causing malaria in man.

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[5] For additional details see Farmers' Bulletin 1070, The Fowl Tick and How Premises May Be Freed From It.

The first stage of the chicken tick's development is passed on the body, the seed tick leaving the birds when it has become engorged; thereafter the adult tick attacks chickens only at night, after they have gone to roost.

Treatment.—Chicken ticks are very persistent, and ordinary insecticides have little effect on them. If the chicken house is badly infested and is not of much value, it should be destroyed by burning. Otherwise, it may be disinfected after all loose boards and boxes which may provide hiding places for the ticks have been removed. Then anthracene oil, crude petroleum, or wood preservative may be applied as recommended for the treatment of red mites. After the general spraying it is usually necessary to apply anthracene oil to the roosts, roost supports, and nests several times at intervals of 3 or 4 weeks.

A simple and inexpensive way of protecting chickens from the attacks of ticks is to provide readily demountable roosts direct from the floor and not touching the walls. These should be painted occasionally with anthracene oil or petroleum. Nests should be located away from roosting places. If constructed of metal, they can be quickly rid of ticks from time to time by burning out the straw.

Metal houses have been found to be effective in dealing with the ticks, as even without special attention they remain practically tick-free, and if necessary they can be disinfected easily by a fire of straw, paper, or other light material, after the removal of the roosts. Metal houses, however, are usually more expensive than wooden ones, and are hot in summer and cold in winter. If they are used in summer the fowls should be provided with shade outside the house.

When ticks have once been eradicated from the premises no chickens should be added to the flock until they have been quarantined for 10 days in temporary coops. The coops should be destroyed after use, or thoroughly treated with anthracene oil.

FLEAS[6]

In the Southern and Southwestern States poultry are frequently infested by a species of flea known as the chicken flea (fig. 28) or sticktight flea, so-called from its habit of remaining attached to one place. This form also attacks dogs, cats, and some wild animals. On poultry the fleas are usually found in clusters on the comb, wattles, and around the eyes; on dogs they are found on the ears. Young fowls when heavily infested often die quickly. Older birds, while more resistant, have been known to succumb to heavy infestations, and even mild infestations reduce egg laying and retard growth.

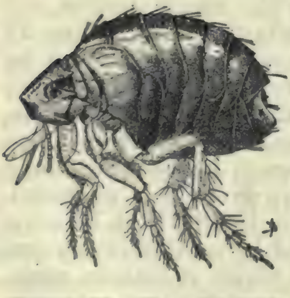

FIGURE 28.—The sticktight flea, adult female. Much enlarged.

Treatment.—As a preliminary step in the treatment of fleas, all dogs and cats should be kept away from the chickens and should never be allowed to lie on the ground in the chicken yards. As rats frequently harbor large numbers of these fleas and may therefore keep up the infestation, they should be destroyed by trapping, not only on account of the fleas they may carry but because they are themselves a serious pest to poultry. Chicken fleas breed in the dust on the floors of henhouses, and on the soil under houses and outbuildings. Hence especial attention must be given to the treatment of the breeding places as well as to the infested fowls. The combs and wattles of the birds may be anointed with carbolated petroleum or sulphur ointment. Great care should be taken, however, not to get any of the ointment in the birds' eyes, as it may produce blindness. The henhouses and yards should be thoroughly cleaned and sprayed with creosote oil. As the fleas breed freely in the dust beneath buildings, it is advisable to exclude poultry and animals from such places.

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[6] For additional details in regard to chicken fleas see Farmers' Bulletin 897, Fleas as Pests to Man and Animals, With Suggestions for Their Control.

THE BEDBUG AND CLOSELY RELATED BUGS

The common bedbug; *Cimex lectularius*, and one of its close relatives, the Mexican chicken bug, *Haematosiphon inodora*, as well as the European pigeon bug, *C. columbarius*, and the barn-swallow bug, *Oeciacus hirundinis*, may attack domestic birds and may become serious pests. The bugs live in the nests or about roosting places, hiding in the cracks during the day and coming out at night to suck the blood of the fowls. They especially annoy sitting hens, sometimes causing them to desert their nests. Since they may gain entrance to houses and cause much annoyance to human beings, their control is doubly important.

Treatment.—These pests can usually be destroyed by the thorough spraying of all cracks of the poultry house with creosote oil or crude petroleum.[7] Poultry houses should be built so as to eliminate, so far as possible, holes and cracks which offer protection to the bugs.

BEETLE LARVAE

There are several different kinds of beetle larvae which may occasionally attack domestic birds. Young pigeons especially suffer from such attacks. The larder beetle, *Dermestes lardarius*, and also the meal worm, *Tenebrio molitor*, have been known to kill squabs by eating away the skin at the vent and neck, thus producing serious sores; and larvae of one of the sexton or burrowing beetles, *Necrophorus* sp., may also attack these young birds. The adult of the meal worm, on the other hand, may greatly annoy sitting hens, attacking their feet. In addition, larvae of the blowflies, *Lucilia* spp. and *Cochliomyia* spp., may be found on domestic birds, the eggs having been deposited by the fly in sores or in the natural openings of the bird's body.

THE PIGEON FLY

In recent years the pigeon fly, *Pseudolynchia maura*, has become a serious menace in many parts of the United States, especially in the Southern States. The flies annoy the pigeons and, when numerous, their bites cause considerable loss of blood; in addition, they transmit the organisms which cause pigeon malaria. See page 46 for details in this connection and for control measures.

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[7] For additional details in regard to the bedbug and its control see Farmers' Bulletin 754, The Bedbug.

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U. S. GOVERNMENT PRINTING OFFICE: 1936

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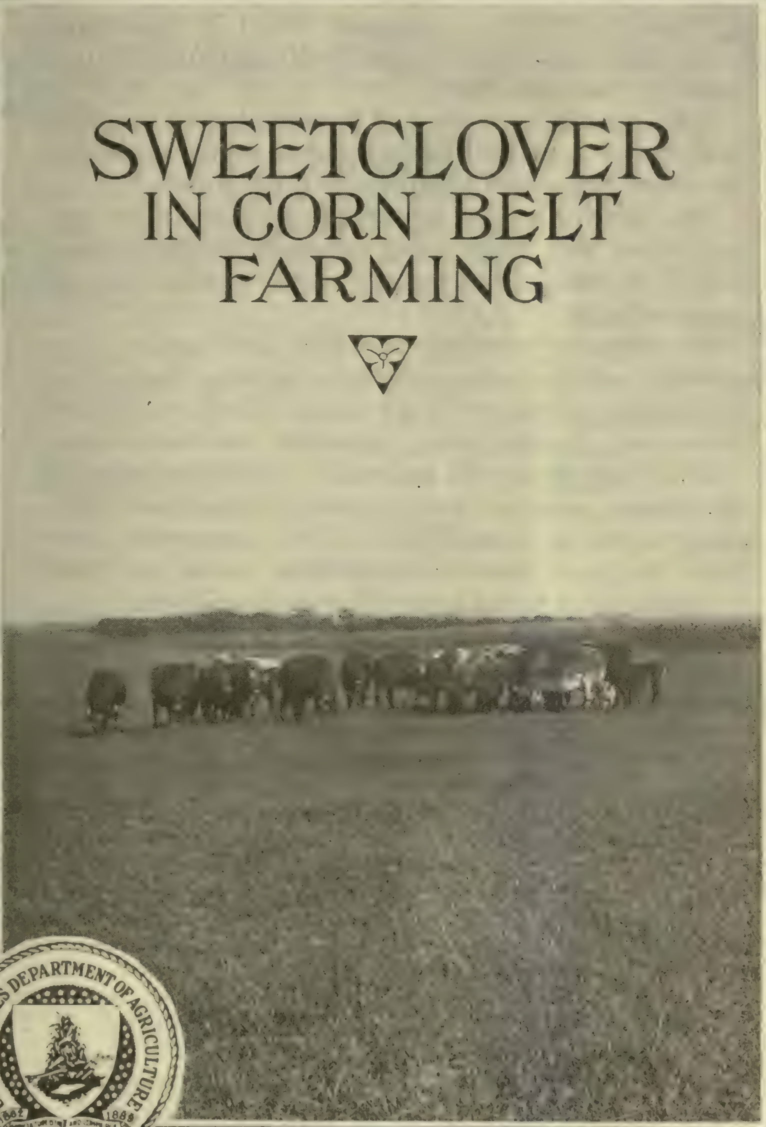
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1653

SWEETCLOVER IN CORN BELT FARMING



1862 1889

SWEETCLOVER, a roadside weed 25 years ago, to-day is a crop of considerable economic importance in the Corn Belt.

It fits readily into most of the established cropping systems of Corn Belt farms, and in many sections is the most important leguminous crop grown.

Sweetclover is used for hay; it produces more pasture than any other crop common to the region; and it is unequalled by any other legume for soil improvement.

If properly handled, the first and second year growths will furnish continuous grazing throughout the growing season. This makes it of exceptional value as a pasture crop, especially for dairy cows.

The purpose of this bulletin is to outline some of the things essential for successful sweetclover production and to present some of the important practices that have been developed on farms on which sweetclover is being most effectively utilized.

Cropping systems are outlined for different types of farming and for different sections of the Corn Belt.

This bulletin is a revision of and supersedes Farmers' Bulletin 1005, Sweet Clover on Corn Belt Farms.

Washington, D. C. **Issued January, 1931**

SWEETCLOVER IN CORN BELT FARMING

By M. A. Crosby, *Assistant Agricultural Economist, Division of Farm Management and Costs, Bureau of Agricultural Economics*, and L. W. Kephart, *Senior Agronomist, Office of Forage Crops and Diseases, Bureau of Plant Industry*

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INTRODUCTION

TREMENDOUS EXPANSION in the use of sweetclover has occurred on Corn Belt farms during the last 10 years.[1] In the early days it was used mainly as a pasture or as a means of restoring fertility to soils that had been depleted by long-continued cropping with corn and small grain, but at present it is well established as a regular crop in the organization of farms in many sections of the Corn Belt. Its outstanding value as a pasture and soil-improving crop, the relative cheapness of seed, and the ease with which it may be fitted into established cropping systems have all contributed to this widespread use of sweetclover.

Naturally the use of sweetclover has increased most rapidly in those sections that possess a neutral or alkaline soil, and where artificial inoculation is unnecessary, but it also has become firmly fixed as a part of the cropping system in many sections in which liming and inoculation are absolutely necessary for its production.

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[1] Two species and one botanical variety of sweetclover are grown in the Corn Belt. Biennial white (*Melilotus alba*), usually called "white" or "common white," and biennial yellow (*M. officinalis*), commonly called "yellow," or "yellow blossom," are the species, and Hubam, an annual variety of the biennial white, is the botanical variety. Grundy County, Arctic, and Essex are smaller and earlier maturing varieties of the biennial white, and Albotrea is a variety of the biennial yellow. The common white biennial is by far the most important and constitutes approximately 85 per cent of all sweetclover grown in the Corn Belt. Unless otherwise indicated, all discussion in this bulletin refers to the common white. As sweetcover reaches maturity in the early fall of the second year the terms "first-year crop" and "second-year crop" are used to designate, respectively, the growth produced the year of seeding and the year after seeding.

Requirements for growing sweetclover are generally known but there continues to be a strong demand for information as regards the most effective methods of utilizing the crop. This bulletin is based on data secured in 1929 from a study of methods of growing and utilizing sweetclover on over 200 Corn Belt farms on which sweetclover had been used from 3 to 18 years, and on several years' field observations.[2] Its purpose is to outline some of the things most essential to success with sweetclover, and to discuss some of the more recent practices that have been developed on farms on which the crop is being most effectively utilized.

ESSENTIALS FOR SUCCESS WITH SWEETCLOVER

Briefly, lime and inoculation are essential for the successful production of sweetclover. The crop can be grown practically anywhere in the Corn Belt if soil acidity is corrected. Inoculation is essential in all sections in which the bacteria required by sweetclover are not already present in the soil. A firm seed bed is also important in securing a satisfactory stand, especially if spring seeding is delayed or late summer seeding is practiced.

LIMING

Lime is the most important single requirement for successful sweetclover production. Sweetclover is highly sensitive to an acid condition of the soil and probably more failures with the crop have been due to lack of lime in the soil than to any other one cause. Fortunately portions of the Corn Belt have soil that is neutral or at least is not acid enough to prevent the successful growth of sweetclover. This is particularly true of northeastern Kansas, eastern Nebraska, southeastern South Dakota, southwestern Minnesota, the river-bottom lands of northwestern Missouri, and a large share of the western portion of Iowa. It is true, but to a lesser extent, of portions of Illinois, Indiana, and Ohio.

Except in localities in which the soil is known to be neutral or alkaline, tests should always be made to determine its lime requirement before attempting to grow the crop.[3] If such a test shows an acid condition of the soil it is unwise to attempt to grow sweetclover without first applying lime to correct the acidity. It may not always be necessary to neutralize an acid soil completely, but sweetclover must have some lime if it is to be grown successfully. This necessity of liming presents a serious problem in many sections for under most conditions liming is an expensive process, from the standpoint of the cost of lime and of the labor required for hauling and spreading. However, many Corn Belt farmers find that the expense of liming for growing sweetclover is more than compensated in the extra returns from crops following sweetclover.

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[2] Acknowledgments are due the numerous farmers from whom data were secured, the county agricultural agents for valuable assistance in making contacts with sweetclover growers in the various sections, and college and experiment station officials in the Corn Belt States for helpful suggestions relative to this study.

[3] Most county agents are equipped to make these soil tests or can advise how to make them.

In a study of liming costs on 31 Corn Belt farms the quantity of lime used per acre ranged from 1 to 3½ tons, the average application being 2.73 tons per acre. The cost of lime varied from $1 to $5.25 per ton, and the cost of lime applied per acre ranged from $2.90 to $7.70. Thus farmers who undertake a liming program must figure on a cash outlay for lime alone of $3 to $8 per acre. Labor required for hauling and spreading varied considerably according to distance of haul and method of spreading, the average requirement being 4.4 man hours and 8.2 horse hours per acre, or 1.6 man hours and 3 horse hours per ton. Few farmers can afford to lime the entire farm in one year or even in one rotation period. On most of the farms from which data were obtained a conservative program was followed and the lime was applied in late summer or fall to land that was to be seeded to sweetclover in the regular rotation the following spring. Farmers' Bulletin No. 921, The Principles of the Liming of Soils, discusses the principles of liming soils.

INOCULATION

Inoculation is important and should not be neglected. In the soils of some sections, particularly in the western and northwestern part of the Corn Belt, the required bacteria are already present, but unless this fact has been fully determined inoculation of the seed or soil is advisable before sweetclover is sown for the first time. In most States inoculating material may be obtained through the county agent, from the State experiment station, or from reliable seed dealers, at a cost amounting to but a few cents per acre. Data from 30 farms show inoculating costs to average 8.9 cents per acre where culture was used, and 4.3 cents per acre where soil was used. Some farmers make a practice of inoculating their sweetclover seed each year, feeling that they can ill afford to risk failure or a poor stand when the cost is so small.

SEEDING PRACTICES

In the Corn Belt practically all sweetclover is seeded with small grain; approximately three-fourths is seeded in spring grain—oats, barley, and flax—and nearly one-fourth is seeded in winter wheat. A few farmers make a practice of seeding alone or in corn at the last cultivation, but as a rule these methods are followed only if some unusual condition prevails; the acreage seeded by these methods is comparatively small.

In seeding with spring grain, sweetclover is commonly sown with the grass-seeder attachment on the drill. This is the easiest and most economical method as only a minimum of additional labor is required. In some sections the usual practice is to mix the sweetclover seed thoroughly with the grain in the seeder box and drill in the sweetclover and grain together. If oats are disked in, on cornstalk land, sweetclover is usually broadcast with an endgate or hand seeder after the oats are sown. The most common method of seeding in winter wheat is to broadcast the sweetclover seed from late January to early March and let the action of frost cover the seed. Others broadcast the seed in late March or April and cover with a light harrow or cultipacker; still others drill the sweetclover seed in the wheat the latter part of April. Seeding sweetclover in small grain is not only economical of labor, but permits greater effectiveness in the utilization of land.

In sections in which the soil is unusually fertile, and in sections in which clover has been grown for several years, the plant frequently grows so rank as to be troublesome in the grain at harvest time. Under such conditions it has been found advantageous to delay sowing sweetclover until two or three weeks after seeding the spring grain. If this method is followed the seed is usually put in with a grain drill or is sown broadcast and covered with a harrow, cultipacker, or rotary hoe.

Seeding sweetclover in corn at the last cultivation has never become popular although under certain conditions this practice is followed, with satisfactory results. This is particularly true of sections in which bottom land is devoted to continuous corn production. (Fig. 1.)

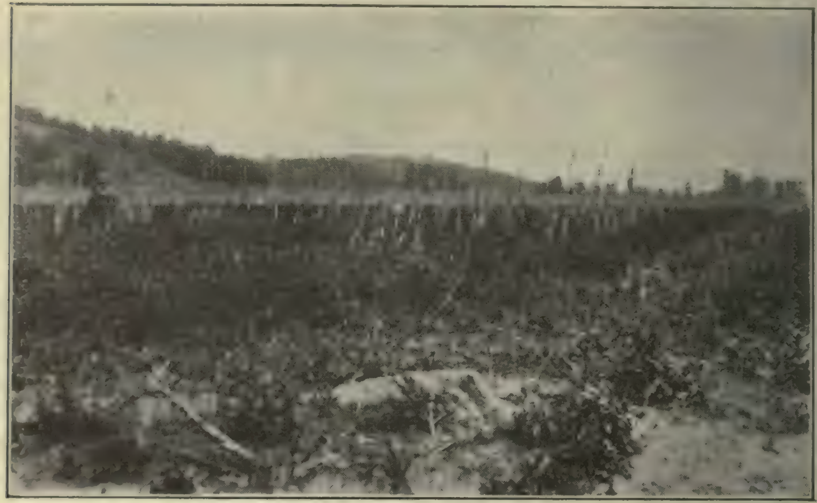

FIGURE 1.—In sections in which river-bottom land is planted to corn each year sweetclover sown in the corn at the last cultivation will be ready to plow under early the following May

Late summer seeding of sweetclover is seldom practiced, although it is as likely to meet with success as is late summer seeding of alfalfa. It is more expensive, and does not result in as strong and vigorous first-year-growth as is secured by spring seeding. The practice has little to commend it except where spring seeding has failed, or where sweetclover is sown as a catch crop. A Nebraska farmer has obtained satisfactory results with a unique method of seeding in small-grain stubble. At harvest time a double disk, a grain drill with sweetclover seed in the grass-seeder attachment, and a smoothing harrow are hooked behind the binder and the whole outfit is drawn with a tractor. By this method the grain is harvested and sweetclover sown at one operation.

In the drier sections of the western portion of the Corn Belt numerous failures result from seeding sweetclover with small grain. The grain crop seriously competes with the clover for moisture.

Where this condition prevails seeding sweetclover alone usually brings better results.

Practically all commercial sweetclover seed is now scarified. Scarified seed germinates quickly and is best for late spring or summer planting. For very early spring or late winter planting scarified seed is less desirable because it is likely to germinate during a brief period of warm weather, only to have the seedlings killed by a subsequent freeze. An increasing practice, particularly in the eastern part of the Corn Belt, is to sow unhulled and unscarified seed on winter wheat in January and February. In the eastern part of the Corn Belt this is one of the most reliable methods of obtaining a stand.

The quantity of seed sown per acre varies from 4 to 25 pounds, the average being 12 pounds. Heavier seedings are usually made when the crop is to be used for pasture or hay and lighter seedings when a seed crop is to be harvested. In some of the more fertile sections, and where sweetclover has been rotated over the entire farm, a seeding of 4 pounds per acre is sufficient. Where unhulled seed is used the rate of seeding is usually a third heavier.

SWEETCLOVER IN MIXTURES

The practice of seeding other clovers and grasses with sweetclover is gaining favor in many sections. Several advantages are claimed for this method. In sections in which a lack of lime in small areas prevents an even stand of sweetclover over the entire field the other plants will fill in the skips where the sweetclover has failed. The presence of the other plants gives variety to the diet of feeding animals, lessens the danger of bloat, helps to bridge over the gap that may occur between the grazing season of second-year and first-year sweetclover, and lengthens the grazing season if the pasture is grazed through the fall of the second year. On soils that heave badly in winter the grass roots tend to protect the sweetclover and lessen the damage to the stand from this source. A further advantage in sections that have a loose, porous soil is that the grasses form a sod that permits a better job of plowing in the fall after the pasture season is over.

SEEDING SWEETCLOVER IN PERMANENT PASTURE

Many Corn Belt farmers wish to use sweetclover as a permanent pasture either in a pure stand or mixed with grass. This is especially true on farms on which rough unplowable land is devoted to grazing. Instances are on record in which this has been successfully accomplished, but the failures to secure and maintain permanent stands of sweetclover far outnumber the successes. The most common causes of failure are acid soil and wrong seeding methods.

In most old fields the soil is sour, and as sweetclover can not grow in sour soil, lime must be added. Merely scattering lime on top of an old sod does not ordinarily improve the land sufficiently. Lime placed on the surface of the ground penetrates scarcely more than an inch even after long weathering, whereas sweetclover roots penetrate 5 feet or more. Unless the lime can be incorporated into the soil by plowing and harrowing, there is little hope of getting a stand on acid soil. If the land can be plowed, the methods of obtaining the initial stand for a permanent field of sweetclover is the same as for any other stand.

On farms so fortunately situated as not to need lime it is possible to obtain a very good stand without plowing. The only requirement is to provide a surface of bare, loose soil upon which the seed may fall and germinate. If the old sod is not too thick this may be done by disking or harrowing early in spring, scattering the seed upon the fresh soil, and covering by rolling or light harrowing. A rather heavy seeding is advisable in such cases. If the sod is thick, with a heavy accumulation of old grass, the field should be burned off late in winter when the grass is dry and the seed disked in or allowed to be covered by the action of frost. It is almost a waste of seed to sow sweetclover on heavy sod without some previous preparation. Most of the seed lodges on the grass, or, if it happens to touch bare soil, germinates but does not take root. The result is a few widely scattered plants too isolated to be of any value.

For permanent pasture purposes a mixture of grasses with sweetclover is usually better than sweetclover alone. Timothy and bluegrass, and in the southern part of the Corn Belt, orchard grass, make good combinations with sweetclover. In localities in which bluegrass comes in readily, this grass may be omitted from the seed mixture, and allowed to come in of its own accord.

Soil of old fields is usually deficient in the bacteria that inoculate sweetclover roots, and these must be supplied by artificial inoculation. The double culture method whereby both soil and laboratory inoculating material are used gives assurance of inoculation.

In attempting to establish a permanent stand of sweetclover it is advisable to plant two years in succession. The first seeding should be heavy—20 pounds of seed per acre is not excessive. The second seeding may be lighter, since some of the previous year's seeding is likely not to germinate until the second year.

If a new pasture is made by seeding a mixture of sweetclover and grasses, it may be pastured lightly the first year, but sweetclover in an old bluegrass pasture should not be grazed the first year. For this reason it is advisable, in old pastures, to seed half of the pasture to sweetclover one year and the other half the next year. The first year's seeding may then be grazed the second year and the second year's seeding grazed the third year. Moreover, the grazing should always be managed so that enough seed will be matured to reseed the pasture each year.

In mixtures of sweetclover and bluegrass, there is a tendency for the bluegrass to increase as it does in an alfalfa field, and crowd out the sweetclover in three or four years. In any case the duration of a sweetclover stand is likely to be shorter if there are other plants in the field than if the sweetclover is alone.

An example of sweetclover being successfully established as a permanent pasture is furnished by a dairy farmer in Lancaster County, Nebr. On this farm, half of a 25-acre native pasture was broken up and seeded with 1½ bushels of oats and 13 pounds of white biennial sweetclover seed per acre in March, 1922. Both oats and sweetclover were grazed from June 15 to October 31, care being taken not to graze the sweetclover too closely. On March 20 the following spring the field was reseeded with sweetclover at the rate of 9 pounds of seed to the acre. That year the field was pastured from the first week in May until freezing weather in the fall, but enough of the second-year sweetclover matured to reseed the field. In 1925 the other half of the field was seeded in the same manner, the 25 acres now furnishing ample grazing for 13 to 15 cows and between 25 and 30 head of young cattle from around April 20 to late fall.

The sweetclover reseeds each year, so there is a good stand of both first-year and second-year plants from early spring until the last of August, and no break in the pasture season. The fore part of the season the cattle graze mostly on the second-year plants, gradually shifting to the new seeding as the older plants become larger and more fibrous. Bluegrass has been coming in, and there is now about a half stand of this grass over most of the 25 acres.

On a neighboring farm a combination of sweetclover and bromegrass (*Bromus inermis*) has been established as a permanent pasture on 8 acres of land. This was seeded in 1925 with 10 pounds of sweetclover and 25 pounds of bromegrass seed to the acre. It was grazed lightly in the fall of the first year and spring of the second year, and then allowed to mature seed. Since then the sweetclover has reseeded each year, and the combination makes an excellent pasture.

UTILIZATION OF SWEETCLOVER

One of the principal purposes in growing sweetclover is to restore or increase soil fertility, but on most farms the crop also serves from one to several other purposes. It is used for hay, pasture, and as a seed crop. Data from 203 Corn Belt farms on which sweetclover occupied an important place in the cropping system showed 27 farms growing the crop for soil improvement alone. On the other 176 farms, in addition to being grown for soil improvement, the crop was used for pasture on 149 farms, for hay only on 16 farms, for seed only on 7 farms, and for both hay and seed on 4 farms. Of the 149 farms using sweetclover for pasture, 92 were using the crop for pasture alone, 32 were also using it for hay, 13 for seed, and 12 for hay and seed. It is when used for pasture as well as for soil improvement that maximum benefits are derived from the crop.

SWEETCLOVER FOR PASTURE

On the majority of Corn Belt farms some phase of livestock production is important, and in those sections in which sweetclover is grown this crop is of outstanding value as a pasture, although there is still some prejudice against it as a grazing crop. As a rule it will carry two or more times as many animals per acre as will bluegrass; hence its use means a reduction in the acreage required for pasture. This is an important consideration on most Corn Belt farms. All classes of livestock are grazed on sweetclover, but it is in more general use as a pasture for dairy cattle than for other farm animals. Most of the sweetclover that is used for pasture is grown in the crop rotation, and grazing practices vary considerably between different sections, as well as between individual farms in the same section. Some farmers make a practice of grazing the first-year crop for two to three months and the second-year crop from early spring until it matures. Others graze the first-year crop in the fall and the second-year crop only until it is plowed under for corn. Still others do not graze the first-year crop, but make full use of the second year. On a few farms sweetclover for pasture is not grown in the regular rotation but on land that is permanently devoted to pasture.

Seeded in small grain in the spring, the first year's growth may be grazed lightly for 60 to 75 days in the fall. First-year sweetclover does not become tough and woody and is relished by all classes of livestock. Under favorable conditions second-year sweetclover can be pastured considerably earlier in the spring than any of the other pasture crops now in common use, with the possible exception of bluegrass. However, the stand may be injured from grazing too early when the ground is muddy. The plants grow very rapidly in the spring and to maintain a good quality of pasture during the spring and summer a sufficient number of livestock should be carried to keep the growth from becoming too rank. (Fig. 2.) One of the principal difficulties in pasturing the second-year crop comes from permitting it to become woody and tough, especially when it is used for hog pasture. Cattle and horses eat the rank growth better than hogs do, but even for these classes of livestock the growth must be kept down if best results are to be obtained. If the second-year crop grows too high, it should be clipped to keep it back and to bring out the new shoots. In clipping with a mower the cutter bar should be set high enough so the plants will be cut above the lower branches. Farmers who are making the most effective use of sweetclover pasture make a practice of adjusting their acreage of the second-year crop to meet the requirements of the livestock to be pastured, or they adjust the number of livestock to the amount of pasture available.

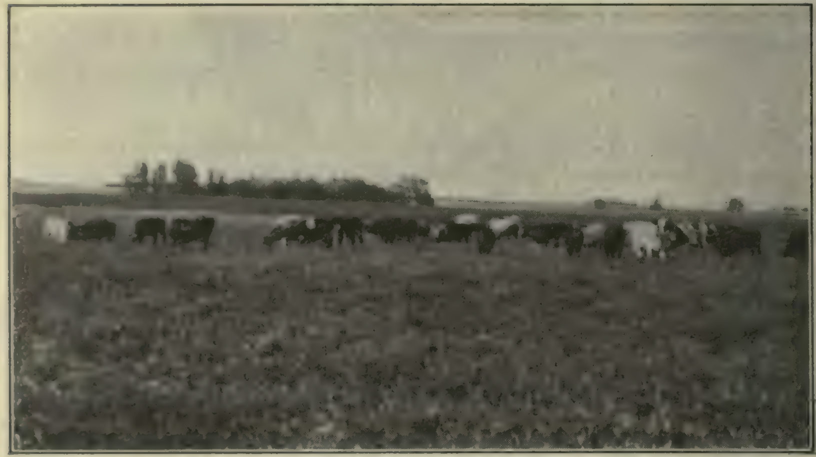

FIGURE 2.—Forty acres of sweetclover provide 90 to 100 days' pasture for 140 head of cattle on this farm. With this heavy grazing the growth is kept down so that the maximum quantity and the best quality of grazing is provided

CARRYING CAPACITY

When pastured to its full capacity a good stand of sweetclover will carry from one to two animal units to the acre through the fall grazing period without injuring the stand.[4] However, it is not advisable to pasture it to its full capacity the first year. On many farms it is the common practice to seed sweetclover in all small grain and pasture the entire seeding in the fall. Under these conditions the farm livestock will frequently have the range of a considerable acreage of sweetclover that was sown primarily for soil improvement. Second-year sweetclover will furnish more grazing than any other pasture crop common to the Corn Belt. When grazed to its maximum carrying capacity it will carry from two to three animal units to the acre (Table 1), and cases are on record in which as many as four animal units have been pastured to the acre for a period of from 100 to 110 days.

Table 1.—*Sweetclover pasture: Farms making most effective use of second-year sweetclover pasture*

State	Acres pastured	Grazing period		Days pastured	Total animal units	Animal units per acre	Total animal unit days	Animal unit days per acre
		From—	To—					
Michigan	9	May 15	Aug. 15	92	24.6	2.73	2,263	251
Do	4.5	Apr. 20	July 30	101	16.4	3.64	1.656	368
Wisconsin	7	June 1	Aug. 30	90	20.0	2.86	1,800	257
Do	6	May 15	Aug. 15	92	16.0	2.67	1,472	246
Do	6	Apr. 15	do	122	17.0	2.83	2,074	345
Illinois	12	May 15	do	92	30.0	2.50	2,760	230
Do	25	May 1	Aug. 30	121	60.0	2.40	7.260	290
Do	35	do	do	121	70.0	2.00	8,470	242
Minnesota	40	May 15	Aug. 15	92	140.0	3.50	12,880	322
Do	10	May 1	do	106	20.0	2.00	2,120	212
Do	15	Apr. 15	Aug. 30	137	32.5	2.17	4,453	297
Do	15	May 10	do	112	39.0	2.60	4,368	291
Do	12	do	do	112	25.0	2.08	2,800	233
Do	9	Apr. 25	Aug. 20	117	18.0	2.00	2,106	234
Iowa	15	May 7	Aug. 15	100	42.0	2.80	4,200	280
Do	10	do	do	100	20.8	2.08	2,080	208
Do	150	Apr. 20	do	117	316.0	2.11	36,972	247
Do	5	May 1	do	106	14.0	2.80	1,484	297
Missouri	12	Apr. 1	do	136	25.0	2.08	3,400	283
Do	22	May 3	Aug. 31	120	60.0	2.72	7,200	327
South Dakota	10	May 1	Aug. 30	121	20.5	2.05	2,481	248
Do	60	do	do	121	180.0	3.00	21,780	363
Nebraska	15	Apr. 15	July 25	101	30.0	2.00	3,030	202
Total	504.5			2,529	1,236.8		139,109	
Average		May 1	Aug. 20	111		2.45		276

The problem of having continuous sweetclover pasture is of much concern to many farmers. With the biennial white the usual grazing period of the second-year crop is from the latter part of April or first of May to August 15 to 30, and for the first-year crop it is from around August 15 to 30 until freezing weather. It would seem, therefore, that there is an overlapping of the grazing periods of the two crops. However, under conditions of extremely dry weather a gap of from 10 to 20 days is likely to occur between the end of the grazing period of second-year sweet clover and the beginning of the grazing period of the new spring seeding. Under normal conditions spring seedlings are large enough to graze by the middle of July or first of August, but it is not always a good plan to pasture this early if maximum benefits are to be derived from the crop the following year. Light grazing may do no damage, but heavy grazing early in the fall is likely to injure seriously the development of the crop the following spring.

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[4] An animal unit is 1 horse, mule, or cow; or 2 yearlings; or 4 calves or colts; or 5 hogs; or 10 pigs; or 7 sheep or goats; or 14 lambs or kids.

A growing practice is to seed all small grain to sweetclover, let the livestock graze over the entire seeding from the middle of August until freezing weather, and the following spring set aside a sufficient acreage to provide the pasture required to carry the livestock through the grazing period of the second-year crop. Under these conditions the new seeding is not grazed heavily enough seriously to retard its development, and a continuous pasture is provided throughout the growing season. If a relatively small acreage of sweetclover is grown, this possible midsummer pasture shortage is avoided by planting a small acreage of Sudan grass to provide grazing from the time the second-year sweetclover matures until it is safe to pasture the new seeding. On some farms a reserve bluegrass pasture is utilized to fill in this gap.

FOR DAIRY COWS

Sweetclover is of exceptional value as a pasture for dairy cows. It not only furnishes more feed per acre than does any other pasture, but also provides an abundance of succulent pasture during the hot, midsummer months, when bluegrass and other pasture is usually unproductive and dairy cows generally suffer from lack of feed. Dairymen who have used sweetclover are generally agreed that cows maintain a better flow of milk on this pasture than on any other grazing crop common to the region.

An example of the value of this pasture for dairy cows is furnished by the St. Francois County Dairy Herd-Improvement Association of Missouri. For the testing year 1928–29 the association included 345 cows, which averaged 278.2 pounds of butterfat per cow, with an average feed cost of $66.90, and an income above feed cost of $90.02 per cow. The winter feed was practically the same for all herds, but four herds, with 45.45 cow years, were pastured on sweetclover during the summer months. These four herds averaged 305.23 pounds of butterfat per cow for the year, at a feed cost of $69.05, and an income above feed cost of $107.32 per cow, or $17.30 per cow above the average for all cows in the association. These four herds, with practically the same cows, were in the test in 1927–28 but did not have sweetclover pasture. Their average butterfat production per cow that year was 282 pounds.

FOR BEEF CATTLE

The claim is sometimes made that beef cattle do not make satisfactory gains on sweetclover pasture alone. This may be true if the plants are allowed to become coarse and woody before the cattle are turned on, but there are numerous cases on record of steers that have put on gains of 2 pounds or more per day on sweetclover pasture alone. It is obvious, however, that the most satisfactory gains are made when the sweetclover pasture is supplemented with a grain ration. A rather outstanding example of this is the case of a baby-beef producer in Cottonwood County, Minn., who pastures on sweetclover exclusively. His practice is to buy calves weighing from 550 to 600 pounds, pasture them on sweetclover for about 75 days, and finish them in the dry lot. The pasture is supplemented with corn. The following is a record of one year's results:

> The last of May, 1928, 56 head of Hereford calves were bought at Milford, Iowa. These calves had been shipped from the sand hills of Nebraska and had been on pasture for a week, so probably had recovered shipping shrinkage. They were weighed at Milford, averaging 586 pounds each, hauled by truck to the farm, a distance of 60 miles, and turned on a 35-acre sweetclover pasture. They were on pasture from June 1 to August 15, a period of 75 days, and then put in the dry feed lot. When taken off pasture they averaged 848 pounds, having made a gain of 262 pounds each, or 3½ pounds per head per day for 75 days. The total gain for the 56 head was 14,672 pounds. While on pasture they were fed 42,000 pounds of corn in self-feeders. Thus, the quantity of corn required for 1 pound of gain while on pasture was 2.86 pounds.

In addition to the 56 beef cattle, 15 dairy cows were also pastured on the 35 acres of sweetclover.

FIGURE 3.—Part of a herd of 189 baby beeves on 120 acres of first-year sweetclover pasture. Sweetclover and oats are sown together about the 1st of April and are grazed from the first week in May until freezing weather

An example of a different system is that of a cattle feeder of Woodbury County, Iowa, who annually feeds out from 175 to 250 steers, and around 200 hogs, and depends entirely on oats and sweetclover for pasture. His cropping system is as follows:

First year	Oats and sweetclover pasture.
Second year	Sweetclover pasture.
Third year	Corn for grain and silage.

From 120 to 160 acres are sown to oats and sweetclover each year. The first year the combination is grazed from around May 1 until freezing weather, and the second year the sweetclover is grazed from about April 1 until the latter part of August.

Calves from 4 to 6 months old and weighing around 325 to 350 pounds are bought in the spring and pastured on the oats and sweetclover through the summer and fall of the first year. (Fig. 3). Usually part of the calf herd is put on heavy grain feed and finished off as baby beef in the fall of the first year. The remainder are wintered in stalk fields and on alfalfa hay and silage, and are turned on the second-year sweetclover as soon as it begins growth in the spring. The cattle have no other pasture, but are fed corn throughout the year. Those carried through the second year are put on full grain ration during the last four to six weeks of the pasture period. Hogs follow the steers the second year.

FOR HOGS

First-year sweetclover makes an excellent pasture for hogs, as does also the second-year crop when it is closely grazed and not allowed to get too rank and woody. According to the South Dakota Experiment Station Extension Circular 258, Sweet Clover for Profit:

> It is especially useful in a three year rotation to provide clean pasture as well as green feed for pigs to prevent losses from roundworms, necrotic enteritis, and other similar parasitic and filth born diseases.

The following experience of a Missouri farmer although outstanding as to results, indicates the general possibilities of the crop for hog pasture.

> On May 1, 1929, 323 head of hogs, weighing 32,525 pounds, were turned on a 40-acre sweetclover pasture. They were left on pasture for 30 days and during this time were fed 750 bushels of corn. When taken off pasture on May 31 they weighed 45,250 pounds, having made a total gain of 12,725 pounds in 30 days. The quantity of corn required per pound of gain while on sweetclover pasture was 3.3 pounds.

FOR SHEEP

Sheep feeders generally report both first-year and second-year sweetclover as superior to other clover or bluegrass as a pasture for sheep. A good stand will carry from 15 to 20 head to the acre. Sheep graze closely and keep the second-year crop down so that the growth is fresh and tender. Sweetclover pasture, either alone or supplemented with a grain ration, is used with excellent results for fattening lambs. Sheep are less likely to bloat while pasturing on sweetclover than while on white, red, or alsike clover.

BLOAT FROM PASTURING ON SWEETCLOVER

Numerous instances of cattle bloating from pasturing on sweetclover have been reported, but the danger from this source is less than when alfalfa, red clover, or alsike clover is pastured. Sweetclover is relatively new as a pasture crop, and for this reason livestock ailments resulting from other causes are sometimes attributed to sweetclover. In several instances fatal cases of reported bloat from sweetclover have turned out to be something entirely different when properly diagnosed. The danger of bloat exists, however, and proper precautions should be taken to guard against this trouble.

Bloating occurs most frequently in May and June, and is due principally to animals gorging themselves on green succulent forage. The best preventive is to make sure that the animals are not hungry when turned into a sweetclover field. While they are on the field they should have free access to a pile of hay or straw or to some mature grass which satisfies their craving for dry feed and prevents their overeating on the sweetclover. In districts that have soft water it is well to keep lime or a good mineral mixture in the drinking water. Even with these precautions a close watch should be kept on the animals during the seasons of rapid plant growth. Animals showing signs of distress should be given immediate treatment with a trocar, a knife, or a vomiting agent.

SWEETCLOVER AS A SOILING CROP

Sweetclover is a valuable soiling crop on dairy farms on which this method of feeding is practicable. A South Dakota dairy company that operates three farms uses second-year sweetclover as a soiling crop exclusively on one farm, and as pasture on the other two farms. For soiling purposes cutting sweetclover begins on this farm when the plants have attained a height of from 12 to 15 inches, and continues each day as long as the clover lasts. As soon as it is cut the green sweetclover is loaded into a feed rack mounted on a wagon and hauled to the feed lot. If care is exercised two and sometimes three cuttings are obtained during the season. The manager states that sweetclover handled in this way will provide twice as much feed per acre as when pastured, and that for highly specialized dairy farms this method of feeding the crop is more satisfactory than pasturing.

SWEETCLOVER FOR BEES

Sweetclover was first used by beekeepers, who sowed the seed in waste places and along the roadsides to provide a honey crop for their bees. The crop is now regarded as one of the best plants for honey production. The quantity of honey produced is large and the quality excellent. Sweetclover has a long blooming season, and the period of nectar secretion usually follows that of red, white, and alsike clover. By sowing both early and late maturing varieties and Hubam, bee pasture can be provided from June until late in the fall.

SWEETCLOVER FOR SOIL IMPROVEMENT

Corn Belt farmers generally recognize the effectiveness of sweetclover as a means of restoring soil fertility and increasing crop yields, and estimates of increases of from 10 to 25 bushels of corn to the acre from plowing under a single crop, or from the use of the crop through one or two rotation periods, are not unusual.

Comparatively few farmers keep accurate record of crop yields, but in 1929 data were obtained from 63 farms on which records had been kept of actual measured yields of corn following sweetclover as compared with the yields obtained in the same field previous to using sweetclover, or of yields in a part of the same field, where corn followed corn or a small-grain crop on land that had never been in sweetclover.

These 63 farms represent two different cropping systems: in one the second-year sweetclover was plowed under as a green-manuring crop, and in the other the sweetclover was pastured, or cut for hay, or harvested for seed, or allowed to mature before being plowed under. (Table 2.)

TABLE 2.—*The effect of sweetclover on corn yields*

Method and soil	Farms reporting	Average yield of corn		Increased yield per acre due to using sweetclover	
		After sweetclover	No sweetclover		
	Number	*Bushels*	*Bushels*	*Bushels*	*Per cent*
Sweetclover plowed under green:					
Poor to medium soil	11	51	31	20	64
Soil in good tilth	14	60	44	16	36
Total or average	25	56	38	18	47
Sweetclover plowed under after maturing:					
Poor to medium soil	18	56	26	30	115
Soil in good tilth	20	63	46	17	37
Total or average	38	60	37	23	62

Figures from the different farms are not strictly comparable, owing to the fact that on some farms the yield of corn produced in the field previous to seeding it to sweetclover was taken as the check, or basic yield, consequently a part of the recorded increase may have been the result of seasonal variation in yield. On other farms the yield of corn following corn or small grain in a portion of the same field, or in a similar field, is taken as the basis of comparison with the yield of corn after sweetclover. In the latter case the results should be more nearly comparable as the yields are of the same year. They may have been influenced to some extent by some slight variation in soil fertility, although as a rule the sweetclover was seeded on land that averaged as low or lower in productivity than that in the check field.

The farms on which sweetclover was plowed under as a green-maturing crop were divided into two groups according to the yield of corn in the check fields. (Table 2.) On the farms in the first group, yields in the check fields averaged 31 bushels to the acre. Yields following sweetclover averaged 51 bushels to the acre, an increase of 20 bushels to the acre. On the farms in the second group, yields in the check fields averaged 44 bushels to the acre, and the yield following sweetclover was 60 bushels to the acre, an increase of 16 bushels to the acre. The average yield on the check fields of the 25 farms of both groups was 38 bushels to the acre, and following sweetclover it was 56 bushels, an increase of 18 bushels to the acre.

The farms on which corn followed second-year sweetclover that had been used for pasture, or harvested for hay or seed, or allowed to mature before being plowed under, were also divided into two groups. On the farms in the first group, yields in the check fields averaged 26 bushels to the acre, and the yield following sweetclover was 56 bushels, an increase of 30 bushels to the acre. On several farms in this group the sweetclover had been seeded on land on which long-continued cropping to corn, or alternating crops of corn and small grain, had reduced yields to a low level. On the farms in the second group, the check yields averaged 46 bushels to the acre, and the yields following sweetclover averaged 63 bushels, a gain of 17 bushels to the acre. The average yield on the check fields for the 38 farms of both groups averaged 37 bushels to the acre and the yield following sweetclover averaged 60 bushels, a gain of 23 bushels to the acre.

Records from several farms, on which sweetclover had been used in the regular cropping system for a period of several years show corn yields to have been increased from an average of 42 bushels to the acre prior to the use, to an average of 68 bushels to the acre after this crop had been used through three rotation periods.

Increase in winter-wheat yields resulting from the use of sweetclover are even more striking than those for corn. Data were obtained from 14 farms on the comparative yields of wheat following sweetclover and of wheat following corn or a small-grain crop. On seven of these farms winter wheat followed a spring seeding of sweetclover that was plowed under in August. The basic yield on these farms was 14.7 bushels to the acre, and the yield following sweetclover was 26.8 bushels, an increase of 12.1 bushels, or a gain of more than 82 per cent. On the other seven farms winter wheat followed second-year sweetclover that, in most cases, had been pastured or allowed to mature before being plowed under. On these farms the basic yield was 11.86 bushels to the acre and following sweetclover the yield was 32.28 bushels, an increase of 20.42 bushels to the acre, or a gain of 172 per cent.

Records from a few farms, on which wheat followed oats or barley in a regular rotation of corn, spring grain, winter wheat, and sweetclover, showed wheat yields to have been increased from an average of 17 bushels per acre to 38 bushels by the use of sweetclover through three rotation periods.

The most striking results were secured on land that originally was highly productive but which had been reduced to a relatively low level of productivity by a system of farming that had depleted the soil of organic matter and nitrogen. Proportionate increases in yields can not be expected on land that is already highly productive. Moreover, in many instances the farmer was led to record the comparative yields simply because of the striking difference that was evident, whereas in instances in which the difference was less apparent no record of yields was kept. As a result such data as were obtainable probably represent extreme cases, and the increased yields are considerably larger than those which would be representative of average conditions.

Nor can it be assumed in all instances that the increased crop production was entirely due to sweetclover. On a few farms the land in sweetclover had been limed in preparation for that crop, and this in itself may have had an influence on the succeeding crop. In other instances it appears that the land in sweetclover was given better preparation than that in the check fields. This is particularly true in the case of wheat, and especially where this crop followed second-year sweetclover. However, even with due allowance being made for all these other considerations the results are sufficiently convincing as to the outstanding value of the crop as an economical and effective means of maintaining production at a high level.

Best results are secured where a green manuring crop of sweetclover is supplemented with an application of superphosphate. The experience of a farmer in Nodaway County, Mo., furnishes an unusual example. After two failures to get a stand without liming, a 20-acre field was limed at the rate of 2.5 tons of ground limestone to the acre in the summer of 1926. The lime cost $2 per ton, and the labor of hauling and spreading cost $2.50 per acre, making the total liming cost $7.50 per acre. The field was sown to winter wheat and in April, 1927, inoculated sweetclover seed was sown on the wheat at the rate of 15 pounds to the acre. The cost of seed, inoculation, and labor of seeding the sweetclover was $1.57 per acre. After wheat harvest, 16 dairy cows and 135 hogs were pastured on the 20 acres of sweetclover from July 7 to October 31. Early in May, 1928, the sweetclover was plowed under, the land double disked, cultipacked, harrowed, and planted to corn. An application of 200 pounds to the acre of 20 per cent superphosphate was made just before the corn was planted, and unfertilized strips were left for checks. The superphosphate cost $2.85 per acre. The unfertilized check strips averaged 80.57 bushels of corn to the acre, and the fertilized land 98.28 bushels. The three previous crops of corn on this field averaged 42 bushels to the acre. On this basis lime and sweetclover increased the corn yield 38.57 bushels to the acre above the previous average, and the application of 200 pounds of superphosphate resulted in a further increase of 17.71 bushels to the acre.

In this instance the increased yield of corn more than paid the total cost of liming, of seeding to sweetclover, and of the superphosphate. This is an unusual case, but, although obviously much greater than can be expected under average conditions, the results serve to point out the possibilities of an effective use of lime, sweetclover, and superphosphate in economical corn production.

SWEETCLOVER FOR HAY

Both first-year and second-year crops are utilized for hay. The second year's crop is used for hay mostly in southeastern South Dakota, southern Minnesota, and the northern third of Iowa, where the first year's growth seldom grows large enough to cut for hay. Over the remainder of the Corn Belt the fall growth of the first year is generally used for hay. Sweetclover hay is put up mostly for home use, but there are some sections in which more or less sweetclover hay is sold locally, principally to cattle feeders.

The fall crop of the first year makes the better quality hay. It is leafier, is finer stemmed, and by many feeders is regarded as practically the equal of alfalfa in feeding value. In some sections it is replacing alfalfa as a hay crop. On farms on which a considerable acreage is sown for pasture or for soil improvement, enough of the first-year crop to supply the farm needs for hay can usually be cut. Moreover, it is harvested at a time when it does not seriously compete with other crops in the use of labor, which is not the case with alfalfa. (Fig. 4.) Hay from first-year sweetclover is likely to be mixed with more or less stubble from the grain crop in which it was sown, but this is not a serious objection if it is for home use. The first year's crop is usually harvested in the same manner as is alfalfa.

Second-year sweetclover is coarser and much more difficult to save in good condition than is the first year's growth. When cut before any blossoms appear, and cured in good condition, it makes a fairly satisfactory hay; but if for any reason the cutting is delayed the hay is likely to be coarse, woody, and of relatively poor quality. Two general methods are followed in harvesting second-year sweetclover for hay. One is to cut with a mower having the cutter bar set as high as possible, and rake into windrows with a side-delivery rake as soon as wilted. The windrows are turned from one to three times, depending on weather conditions. When thoroughly cured the hay is put in stacks with buck rakes and a stacker. Another method, and one which is probably more generally followed, is to cut with a binder. The bundles are set up six to eight to the shock, and are stacked when thoroughly cured.

Yields of the hay vary considerably. Records of yields from 31 farms on which first-year sweetclover was cut for hay ranged from three-fourths of a ton to 1.4 tons to the acre, the average being 1.2 tons. Yields reported from 29 farms on which the second-year crop was cut for hay ranged from three-fourths of a ton to 2.7 tons to the acre, the average being 1.5 tons per acre.

FIGURE 4.—The first-year crop of sweetclover may be cut for hay just before corn husking. At this time of the year haying does not interfere with other farm work

DANGER FROM SWEETCLOVER HAY

Farmers in the Corn Belt have learned to use caution in feeding hay made from second-year sweetclover, owing to occasional outbreaks of a strange disease following its use. The disease, which occurs more commonly in young cattle than in other classes of livestock, manifests itself by loss of clotting power of the blood, the afflicted animals bleeding to death from minor wounds or from internal hemorrhage. The cause of the disease is not known. It is thought to be associated with some spoiled condition of the sweetclover hay, but the nature of the spoilage is not known nor is it always visible. The disease has never been known to follow the use of sweetclover hay made from the first-year crop.

Sweetclover disease is most likely to occur when hay is fed exclusively for a considerable time. Supplementing the hay with other roughage and changing the feed every three or four weeks usually seems to be effective in preventing the trouble, although it has been known to occur from feeding a mixed hay containing sweetclover.

SEED PRODUCTION

Because of the uncertainty of yield, difficulty of harvesting, and relatively low price of seed, the production of sweetclover seed is not generally regarded as a dependable enterprise for the Corn Belt proper. Many farmers who formerly made a regular practice of saving a seed crop now depend on obtaining their seed supply from sections in which seed production is a specialty, or they save enough for their own needs from their pasture, or from the second growth after a cutting of hay has been made from second-year sweetclover. Others obtain their seed supply from volunteer plants in their small grain, the sweetclover seed being screened out of the grain at threshing time.

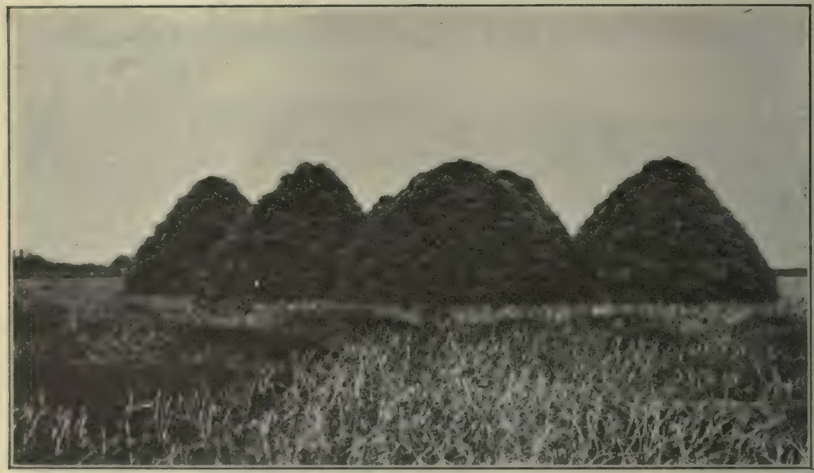

FIGURE 5.—A crop of sweetclover harvested for seed, stacked, and ready for threshing

When grown for seed the most common method of harvesting the crop is with an ordinary grain binder. The bundles are shocked like small grain or left on the stubble until dry enough to thresh. Some thresh out of the field and others stack the bundles and thresh later. (Fig. 5.) The threshing is usually done with an ordinary grain separator equipped with special clover screens or a huller attachment.

Owing to its large growth, the common white biennial is difficult to harvest with a binder. If this variety is saved for seed the first growth of the second year should be pastured, cut for hay, or clipped and left on the ground. This will insure more uniform ripening of seed and make the crop easier to handle with a binder.

Yields vary greatly, the acre yields reported for 1928 ranging from 30 to 450 pounds for common white biennial; from 120 to

540 pounds for Grundy County white; and from 35 to 495 pounds for yellow biennial. For a full discussion of seed production see Farmers' Bulletin 836, Sweet Clover: Harvesting and Threshing the Seed Crop.

PLOWING UNDER SWEETCLOVER

The time to plow under sweetclover is determined largely by the purpose for which it is grown, or by the place it occupies in an established cropping system. If grown mainly for restoring the fertility of badly depleted soil it is usually allowed to go to maturity before being plowed under. It may be utilized for pasture or hay, or harvested for seed; when handled in this way it is plowed under in the fall of the second year or the spring following, depending on whether fall or spring plowing is the more desirable. If the crop is left to mature and no use is made of it the second year the mass of dead vegetation may be difficult to plow under. In such cases it will be necessary to roll down and break up the dead stalks if a good job of plowing is to be done. A cultipacker is probably the most effective implement for this work, but it must be used when the stalks are dry.

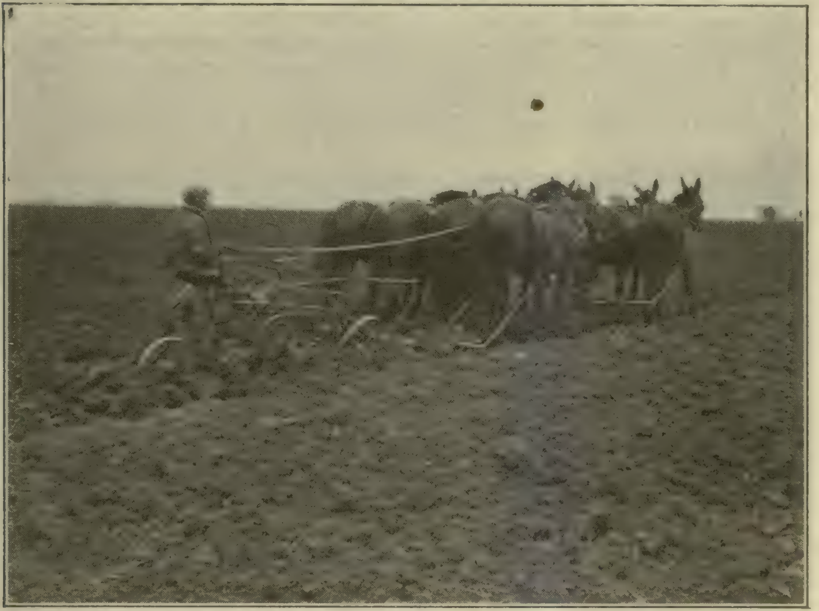

FIGURE 6.—The plowing under of second-year sweetclover should be started by the time the new growth is from 5 to 6 inches high, and for best results should be completed before the plants are more than 15 to 18 inches in height

Sweetclover grown as a green-manure crop for corn is usually plowed under in the spring of the second year. From the standpoint of securing maximum fertilizing value it should be plowed under when the new growth is from 6 to 15 inches tall, for at this stage the maximum quantity of plant food is stored in the roots and stems. (Fig. 6.) More organic matter is added to the soil by plowing under later, but the quantity of nitrogen is not increased. Data secured in Ohio indicate that approximately 80 per cent of the maximum quantity of nitrogen is found in sweetclover about May 1. At this time the plants contain from 3 to 4 per cent of nitrogen; in July they contain but 1.5 to 2 per cent.[5]

Late plowing under has other disadvantages. It is often difficult to turn under the heavy growth and do a good job of plowing. Moreover, the heavy growth is likely to deplete the soil moisture to the detriment of the succeeding crop. This is especially true in the western part of the Corn Belt.

If winter wheat follows a catch crop of sweetclover it is obvious that the latter must be plowed under early in the fall. Fall plowing of first-year sweetclover for corn is also desirable under certain conditions. In some sections corn succeeds better with fall plowing than on land plowed in the spring. Furthermore, if a considerable acreage is to be plowed under too much work comes at one time if the plowing is left until spring. Where these conditions prevail farmers follow the practice of plowing under all or a part of their crop in the fall of the first year. However, fall plowing first-year sweetclover has two real disadvantages. If the plowing is done late in the fall the fertilizing value will be nearly as great as if plowed under in the spring, but the sweetclover is likely to come up and be troublesome in the succeeding crop. If corn follows late fall-plowed sweetclover considerably more labor must be expended in the preparation and cultivation of the crop, and if the spring grain follows there is likely to be more sweetclover than grain. (Fig. 7.) If the plowing is done early, say by the middle of Sep-

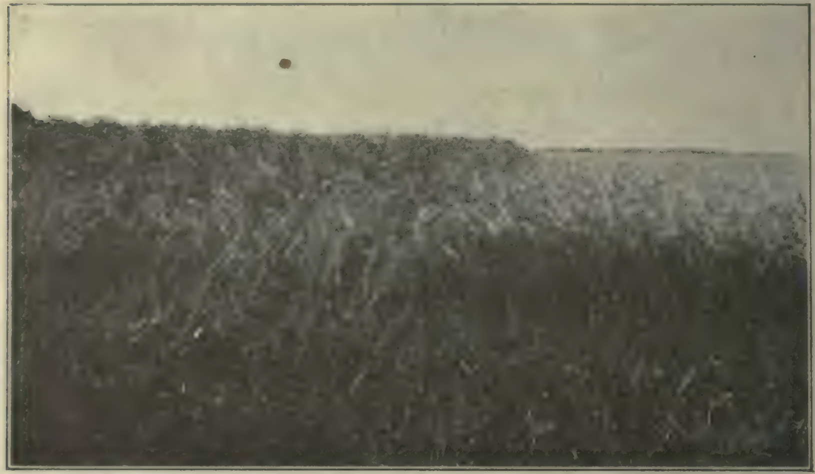

FIGURE 7.—Sweetclover plowed under late in the fall of the first year, or before it starts growth the following spring, is almost sure to interfere with the succeeding crop. On the left is shown the result of plowing under sweetclover too early in the spring

tember, there will be much less danger of the sweetclover volunteering enough the following spring to be troublesome, but the maximum quantity of nitrogen will not be secured.

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[5] Ohio State University Extension Bulletin No. 55, Sweet Clover.

SWEETCLOVER IN CORN BELT CROPPING SYSTEMS

Sweetclover has become a fixture in the cropping systems that prevail in many sections of the Corn Belt. The general characteristics of the plant have made it an easy matter to dovetail sweetclover into most cropping systems common to various sections of the region, and have made possible the adjustment of cropping systems in such manner as to increase their effectiveness. It fits readily into either short or long rotations, and may be rotated over the entire farm in a comparatively short time. The type of farming, type of soil, length of growing season, and the use to which sweetclover is put largely determine the place of this crop in Corn Belt cropping systems. On grain farms a small acreage will provide all the hay and pasture needed, thus leaving the major portion of the crop to be plowed under for soil improvement. On combination grain and livestock farms the pasture requirements are greater and the sweetclover is usually grazed through the second year, and the residues plowed under for soil improvement.

The following rotations or cropping systems are now in common use in various parts of the Corn Belt. These cropping systems have been worked out by farmers to suit conditions generally prevailing in the different sections, and in each section there will be found individual farmers who have worked out various modifications of the usual rotation to fit conditions existing on their own farms.

ROTATIONS FOR GRAIN FARMS WITH SWEETCLOVER FOR SOIL IMPROVEMENT

TWO-YEAR ROTATIONS

The simplest type of cropping system is found in those sections in which the usual practice is to alternate corn and small grain in a two-year rotation. On these grain farms sweetclover is used primarily as a catch crop for soil improvement, and as such does not call for any readjustment of the established cropping system. The rotation is as follows:

First year	Corn.
Second year	Small grain—oats, barley, or wheat—seeded to sweetclover.

Seeded with small grain in the spring, sweetclover normally makes a vigorous growth after the grain is harvested, and may be pastured in the fall, or, as is the case on many farms, particularly in the southern part of the Corn Belt, all or a portion of the fall crop may be cut for hay. On the average-sized farm the acreage in sweetclover is sufficient to provide all the hay and fall pasture required. As a rule the crop is plowed under in the spring of the second year for corn. In some sections, where the acreage to be plowed is large, a portion of the crop is plowed under in the fall of the first year and the remainder the following spring.

THREE-YEAR ROTATIONS

In other cash-grain areas 3-year rotations are in general use. The most common of these is found where corn occupies approximately two-thirds of the crop land. Such a rotation is as follows:

First year	Corn.
Second year	Corn.
Third year	Small grain—oats, barley, or wheat—seeded to sweetclover.

This is a very satisfactory rotation for the more fertile areas in which one leguminous crop in three years is sufficient to maintain soil productivity. A modification of this system is used in some sections, particularly in the eastern part of the Corn Belt and in other localities where the commercial production of soybeans is becoming increasingly important. This is as follows:

First year	Corn.
Second year	Soybeans, or part soybeans and part corn.
Third year	Small grain—oats, barley, or wheat—seeded to sweetclover.

Under each of these systems sweetclover is handled in the same manner as in the 2-year rotation. One advantage these systems have over the 2-year rotation is that the acreage of sweetclover to be plowed under in the spring is proportionately less, thus permitting a better distribution of labor.

In sections in which small grain, particularly winter wheat, is a dominant crop a common 3-year rotation is:

First year	Corn.
Second year	Small grain—oats or barley.
Third year	Small grain—usually wheat—seeded to sweetclover.

The modifications of this system are varied and numerous. Some make a practice of growing wheat two years in succession, seeding sweetclover in the second crop. Some sow sweetclover in both small-grain crops, that sown in the first crop being plowed under in late July or August in preparation for winter wheat.

FOUR-YEAR ROTATIONS

Four-year rotations on grain farms are more commonly found in sections in which corn and small grain are of approximately equal importance, and in which the soil is generally in a relatively high state of productivity. The usual rotation is as follows:

First year	Corn.
Second year	Corn.
Third year	Small grain—usually oats.
Fourth year	Small grain—usually wheat—seeded to sweet clover.

This is the rotation recommended in the so-called "Illinois system of permanent soil fertility." As with the 3-year rotations, several modifications of the system are in use. One is where soybeans are substituted for the first small-grain crop. Another is where sweetclover is seeded in both small-grain crops and handled in the same manner as outlined in the third 3-year rotation. A practice followed by some, which has considerable merit, is to seed Hubam sweetclover in the first small-grain crop. Being an annual, this variety makes a growth that has considerable fertilizing value by the time it is plowed under for the fall seeding of wheat; another advantage is that it is killed by this plowing and does not volunteer in the wheat the following spring.

SWEETCLOVER IN CROPPING SYSTEMS ON GRAIN AND LIVESTOCK FARMS

On combination grain and livestock farms sweetclover occupies a more important place in the cropping system than on grain farms. It serves as the main source of pasture and hay, as well as a soil-improvement crop. By utilizing both the first-year and second-year crops, continuous grazing for the livestock is provided from early spring until late in the fall. As a general rule both first-year and second-year crops are used for pasture, although the first-year crop is not grazed so extensively in the eastern and northern parts of the region as in the central and southern portions. On many farms the acreage sown to sweetclover is considerably more than is needed for pasture, especially for the second year, when from one to three head of cattle can be carried to the acre. Under these conditions it is a common practice to set aside an acreage of the second-year crop sufficient to supply the pasture needs and cut the remainder for hay or seed, or for both. Hay to supply the farm requirements is usually made from the first-year crop except along the northern border of the Corn Belt, where the first year's growth seldom grows large enough for this purpose. In the latter case a portion of the second-year crop is utilized for hay.

THREE-YEAR ROTATIONS

A 3-year cropping system in which corn, oats, barley, and sweetclover are the principal crops appears to meet best the requirements of farms on which some phase of livestock production is the major enterprise. The following is the usual rotation:

First year	Corn.
Second year	Small grain—usually oats and barley—seeded to sweetclover.
Third year	Sweetclover for pasture, hay, and seed.

This cropping system is in more general use than any other; approximately one-fourth of all farms studied, and more than two-third of those in southern Wisconsin, south Minnesota, and southeastern South Dakota, were using it. This system appears to be especially adapted to conditions in the northern part of the Corn Belt, and the abundance of pasture it provides makes it particularly suitable for farms on which dairying is of outstanding importance.

FOUR-YEAR ROTATIONS

Four-year cropping systems on combination grain and livestock farms are of two rather distinct types, one being confined more generally to the eastern and the other to the western part of the Corn

Belt. Various crop combinations are used in each; the following is the most common in the eastern sections:

First year	Corn.
Second year	Small grain—oats or barley.
Third year	Small grain—usually wheat—seeded to sweetclover.
Fourth year	Sweetclover pasture.

Sweetclover is not so commonly used as a hay crop in the eastern part of the Corn Belt and for this reason a variation of this rotation that is not unusual, especially on dairy farms, is to substitute soybeans for hay for all or a part of the small grain the second year. On other farms a practice is made of seeding sweetclover as a catch crop in the first crop of small grain and plowing this under for wheat.

The 4-year cropping system most common to western sections of the region, and in fact the one in more general use than any one system except the 3-year rotations outlined on page 22 is as follows:

First year	Corn.
Second year	Corn.
Third year	Small grain—usually oats and barley—seeded to sweetclover.
Fourth year	Sweetclover pasture.

This system is rather general in sections in which corn is the dominant crop, and in which cattle feeding is an important enterprise on the farm. It is probably followed more closely than the 4-year system common to eastern sections of the region.

FIVE-YEAR ROTATIONS

Five-year cropping systems are followed on many farms. These systems are generally more varied than are the shorter rotations and frequently have been adopted to meet peculiar conditions existing in a relatively small section or on an individual farm. The most common 5-year rotation is as follows:

First year	Corn.
Second year	Corn.
Third year	Small grain—usually oats or barley.
Fourth year	Small grain—wheat or oats—seeded to sweetclover.
Fifth year	Sweetclover pasture or seed.

On some farms a practice is made of seeding sweetclover in the first small-grain crop and plowing this under in preparation for winter wheat. In sections that have exceptionally strong cornland, as in the Missouri River Valley of western Iowa and northwestern Missouri, the usual 5-year rotation used is corn three years, small grain one year, and sweetclover one year. Another system, and one that is better for soils of average fertility, is:

First year	Corn.
Second year	Small grain—usually oats—seeded to sweetclover.
Third year	Corn.
Fourth year	Small grain—wheat or oats—seeded to sweetclover.
Fifth year	Sweetclover pasture or seed.

The advantage of this system lies in the fact that a sweetclover crop precedes each corn crop. If sweetclover is harvested for seed, or allowed to mature seed in the pasture, it frequently happens that this crop will volunteer in the first crop of small grain, but with the present low cost of seed it is not advisable to depend on securing a volunteer stand.

From the standpoint of efficient use of land and labor this is one of the best rotations for Corn Belt farms. It provides (1) a crop of sweetclover before every crop of corn, (2) equal distribution between fall and spring plowing, (3) not more than one-fifth of the land to be plowed at any one time, and (4) twice as many acres of first-year sweetclover pasture as of second-year.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1654

INSECTS *of the* PECAN *and how to* COMBAT THEM

1862 1889

THE CULTURE of pecans in the South has developed rapidly in the last few years and is now looked upon as one of the great horticultural enterprises in that region. With this development has come an increase in the number and destructiveness of the various insects attacking the pecan.

There are insects attacking the nuts, insects injuring the foliage, and insects damaging the trunk and branches. In fact, all parts of the tree are subject in varying degrees to the attacks of different forms of insect life.

It is the aim of this bulletin to present information which will enable the pecan grower to recognize these pests and take the necessary measures for their control.

This bulletin is a revision of and supersedes Farmers' Bulletin No. 1364, Important Pecan Insects and Their Control.

Washington, D. C. January, 1931

INSECTS OF THE PECAN AND HOW TO COMBAT THEM[1]

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INSECTS INJURING THE NUTS

THE PECAN NUT CASE-BEARER

PERHAPS the most serious pest with which the pecan grower has to contend is the pecan nut case-bearer (*Acrobasis caryae* Grote, formerly erroneously called *Acrobasis hebescella* Hulst). The successful control of this insect is one of the problems confronting the pecan industry. In its larval or "worm" stage it attacks for the most part the immature nuts, one larva often destroying several nuts before attaining its full growth, thus greatly reducing the crop in a severe infestation.

This insect has often been reported as destroying from one-third to three-fourths of the total crop of wild pecans in various localities in Texas. It is also present in Florida, southern Georgia, Alabama, Mississippi, and Louisiana, where it occasionally becomes a serious pest. In view of the large acreage of pecan orchards now bearing or coming into bearing, it probably will sooner or later prove a formidable pest throughout the greater part of the pecan belt.

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[1] This bulletin is based in part on information contained in Farmers' Bulletin No. 1364, Important Pecan Insects and Their Control, by John B. Gill. Certain sections of the earlier bulletin have been incorporated in this bulletin with only slight changes; these include the sections relating to the pecan cigar case-bearer, pecan bud moth, fall webworm, walnut caterpillar, belted chion, and oak pruner. Many of the illustrations are the same as those used in Farmers' Bulletin 1364; in addition, a number of illustrations are credited as follows: Figure 1, J. B. Gill; Figure 21, A, H. G. Hubbard; Figure 21, B, A. W. Morrill; Figure 23, T. H. Jones; Figure 50, F. H. Chittenden; Figures 60 and 61, R. W. Leiby; Figure 70, T. H. Snyder.

NATURE OF INJURY

The small larvae that have passed the winter in tiny cocoons usually attached to the buds cause damage in early spring by attacking the tender shoots into which they tunnel. Many of these shoots wilt and turn brown and may be broken off by the wind. (Fig. 1.) Such injury is not serious as compared with the damage caused by the first and second generation larvae, which confine their attacks to the immature nuts.

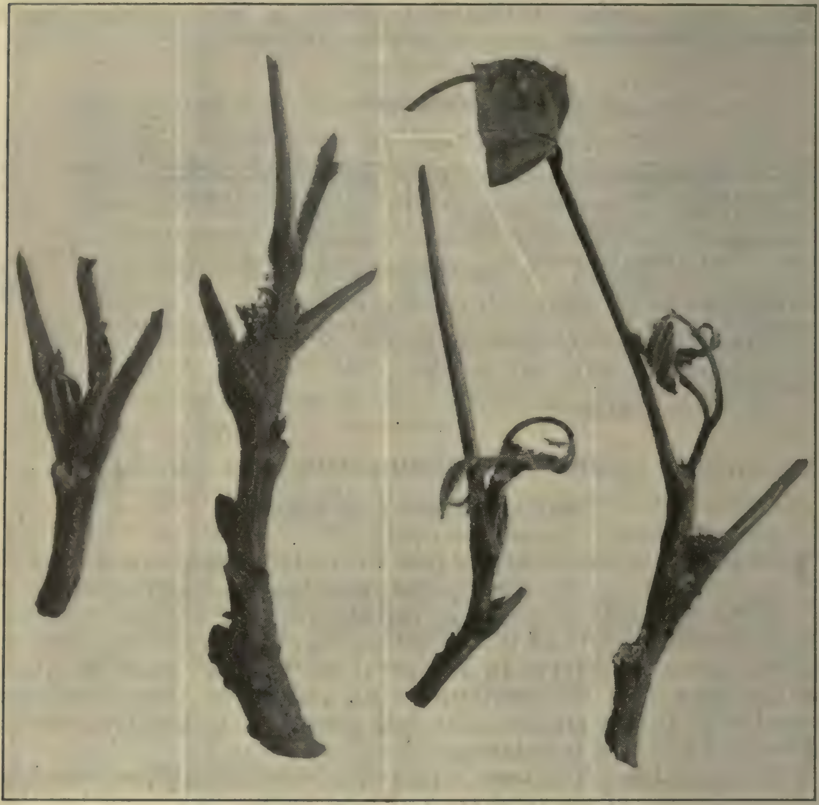

FIGURE 1.—Pecan shoots showing spring injury by larvae of the pecan nut case-bearer

The first-generation larvae make their appearance in May and bore into the recently set nuts. At the point of attack they cast out pellets of frass or borings. (Fig. 2.) These borings are held together by means of fine silken threads, eventually forming a short silk-lined tube. Injured nuts always show the characteristic mass of frass protruding from the place where the larvae gained entrance, which is invariably near the stem end. The larvae of the second generation attack the nuts in the same manner as do those of the first generation, but the loss to the crop is not so great because of the size of the nuts at the time of attack. (Fig. 3.) Early in the season a single larva may destroy several nuts before attaining full

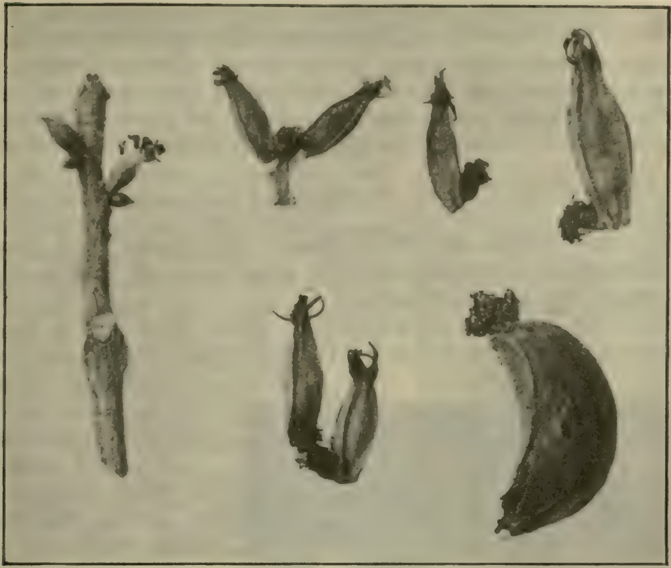

FIGURE 2.—Buds and young pecan nuts showing injury by larvae of the pecan nut case-bearer

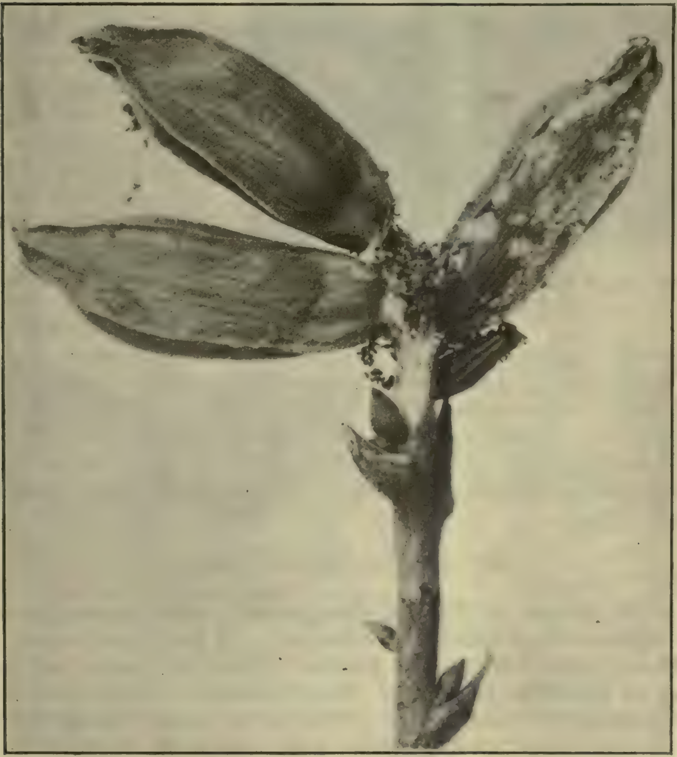

FIGURE 3.—Cluster of pecan nuts infested by the pecan nut case-bearer

growth, while later in the season one or two nuts appear to be sufficient for its development. The larvae of the third generation, which make their appearance in the late summer, usually feed very little. They seem to prefer the shucks, and in these they gnaw only through the surface, forming small, narrow tunnels of frass particles. Such injury does not interfere with the normal development of the nuts.

DESCRIPTION

During the course of development the pecan nut case-bearer passes through four stages; namely, egg, larva or "worm," pupa or resting stage, and adult or moth.

The egg (fig. 4) is oval in outline. When first laid it is greenish white, but as incubation advances the color changes to a reddish tinge, iridescent in some lights. The eggs average one-fiftieth of an inch in length.

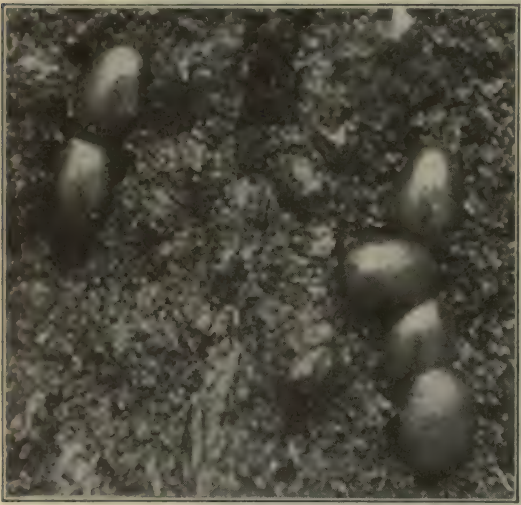

FIGURE 4.—Eggs of the pecan nut case-bearer. Enlarged 30 diameters

The full-grown larva or worm (fig. 5 at right) is about one-half inch long, and its general color is a dirty olive green. The body is sparsely covered with fine whitish hairs, and the skin is wrinkled. The head and mouth parts are dark brown, and the neck is pale brown.

The pupa or resting stage (fig. 5 at left) when first formed has a decided olive-green cast, but later is brown and without striking markings. It is about one-third of an inch long.

The moth or adult (fig. 6) is dark gray. The head and thorax are blackish gray. The forewings are gray and each has a ridge or tuft of long dark scales extending across it near the middle. The hind wings are much brighter than the forewings and without conspicuous markings. The abdomen is light gray. The moths measure from nine-sixteenths to twelve-sixteenths of an inch across the expanded wings.

SEASONAL HISTORY AND HABITS

Immature larvae of the nut case-bearer pass the winter in small tightly woven cases similar to those of the leaf case-bearer. (Fig. 32.) These cases are usually located where the buds join the stem and may be attached to either. Larvae become active in the spring, usually during the latter part of March or early in April, depending upon the season and latitude, and commence to bore their way out. They at once attack the young tender shoots (fig. 1) and bore into them where a leaf joins the main stem.

The larvae feed within the pecan shoots for two weeks or more and then transform to pupae within their tunnels. After a pupal period which ranges from 11 to 18 days, the moths developing from the overwintering larvae appear usually between May 7 and 24, but here again the season and latitude influence the emergence. The emergence of the maximum number of moths coincides somewhat with the setting of the nuts. The dates given above are based on investigations near the southern boundary of Georgia.

The eggs are invariably deposited on the outer end of the nut, and usually at or near the base of the calyx lobes. From 7 to 10 days are required for the eggs to hatch. The first-generation[2] larva, immediately upon hatching, crawls about looking for a suitable place to spin a web. A protected place is chosen where it is convenient for the larva to enter a nut. This is usually where the nuts join to to make up a cluster. In making its flimsy web the larva attaches the strands of silken threads to a number of nuts and to the stem supporting the cluster. This silken inclosure probably serves as a protection from the attacks of predatory and parasitic insects while the larva is entering the small nuts.

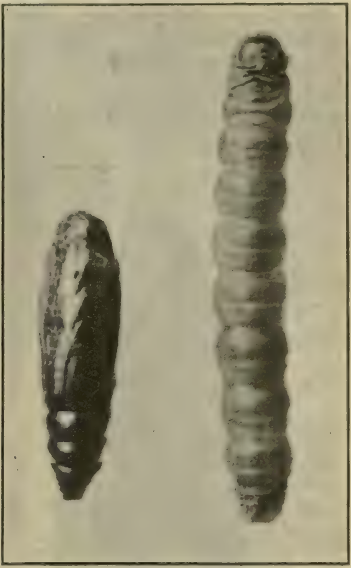

FIGURE 5.—Pupa and larva of the pecan nut case-bearer: Pupa at left (enlarged 3 diameters), larva at right (enlarged 5 diameters)

Some of the larvae may begin feeding on the buds below the nut clusters, in the axils of the buds and stems, and later leave to attack the young nuts. The larva, whether small or practically mature, does not feed on the outer layers of the nut or bud; before entering, it bites out many small pieces and casts them aside, and does not begin to eat until its head is well imbedded in the tissues. These greenish-yellow particles of the outer layer, gnawed off by the larva in entering the nut, later make up part of the tubelike mass which is seen in Figure 2 protruding from the base of the nuts. This has been called a case, although it is not a true case like that constructed in the

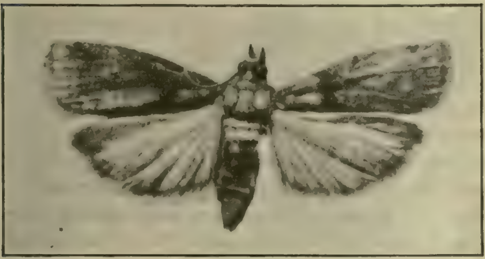

FIGURE 6.—Moth of the pecan nut case-bearer. Enlarged 4½ diameters

spring by the pecan leaf case-bearer. The greenish-yellow particles of the outer layer may be readily distinguished from the remainder of the tubelike mass which is composed of darker colored particles of excrement.

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[2] In discussing the life history of a species a generation is considered to begin with the egg stage and to end with the adult or moth.

The larva as it feeds in the nut stops occasionally to line the mass of frass and excrement with silken threads. Often the tubelike mass may extend so far out that it joins another nut and is attached to it by the larva. In entering each succeeding nut attacked, the larva goes through the same process, not consuming any of the outer layer. The tubelike mass of frass, being attached to several small nuts, serves as a protection to the larva by holding the nuts together in the cluster and preventing them from dropping to the ground.

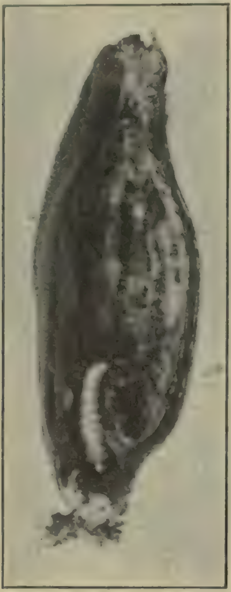

FIGURE 7.—Pecan nut infested by larva of of the pecan nut case-bearer

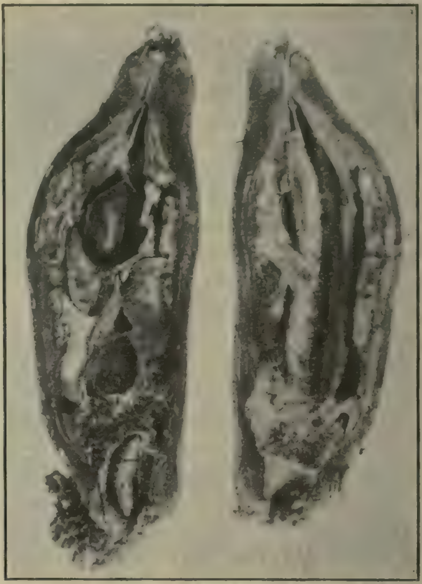

FIGURE 8.—Opened pecan nut showing location of the pupa of the pecan nut case-bearer

A larva of this brood feeds in from two to five nuts during the larval period, which lasts from 22 to 29 days. Upon reaching full growth the larva pupates or transforms to the resting stage within one of the small nuts which it has hollowed out. The pupal period of this generation is from 9 to 13 days. All of the moths in a large series under observation during 1914 to 1917 emerged during the period from June 11 to July 16, but the maximum emergence occurred during the last week in June. The eggs deposited by these moths are also laid upon the nuts.

Most of the second-generation eggs hatch during the last week in June and the first 10 days of July. The larvae of this generation likewise feed within the nuts. (Fig. 7.) The average length of the larval stage for the second generation is 25 days, and the pupal period averages about 10 days. Pupation takes place within an infested nut (fig. 8), and most of the moths of the second generation appear during the first three weeks in August. At Brownwood, Tex., it has been observed that upon hatching some of the larvae of this generation migrate to the leaves to do their first feeding and later attack the nuts. Some of the larvae of this generation, after feeding a little, may construct their hibernation or winter cases and go into the dormant condition.

The larvae of the third generation feed lightly upon the shucks and do little or no damage to the nuts, which usually are beginning to harden at this time. The larvae do not mature now, but after feeding for a time they leave the nuts to construct their hibernation cases. Usually there are but three generations of this insect in a year. At Brownwood, Tex., four generations have occurred in some years. At that place the third and fourth generation larvae feed to some extent on the leaves and tender shoots as well as on the shucks.

The approximate time of the different stages and activities of the pecan nut case-bearer in northern Florida are shown in Figure 9. The periods, however, will vary according to the locality and season.

CONTROL

Considerable study has been devoted to the problem of controlling the pecan nut case-bearer, but no satisfactory control measures can be recommended. Lead arsenate, alone and in various mixtures, has been recommended for this pest and is still being recommended by some investigators. The results obtained by spraying have been somewhat variable, and in most instances the degree of control has not been very marked. Some pecan growers who have used lead arsenate against this pest have not met with success after several years of trial and have discontinued its use.

The feeding habit of the larva makes it difficult to control this insect by spraying with lead arsenate. As the larva does not consume the outer layers of the nut bearing the insecticide, it is natural to assume that the larva will escape getting the poison.

Laboratory experiments which were made in conjunction with field experiments showed that lead arsenate applied to clusters of nuts either as a dust or spray did not deter the larvae from entering, and they seemed to pay little attention to its presence on the clusters, as was shown by the rapidity with which, in most cases, they commenced feeding after being placed on clusters of small nuts. The larvae went through the same process of casting aside the bites of the outer layers whether the nuts were treated or not.

Therefore, before there can be any hope of killing this larva with a stomach poison, some poisonous substance must be found which the larva will consume. An ideal poison would be one which the larva prefers to its normal food.

Traps and attractants: Some mention has been made in the past in various publications concerning the attraction of adults of the pecan nut case-bearer to sweetened mixtures. Such articles have usually been published by growers who have claimed great success for the method. The writers have experimented extensively, both at Thomasville, Ga., and Brownwood, Tex., with the following sub-

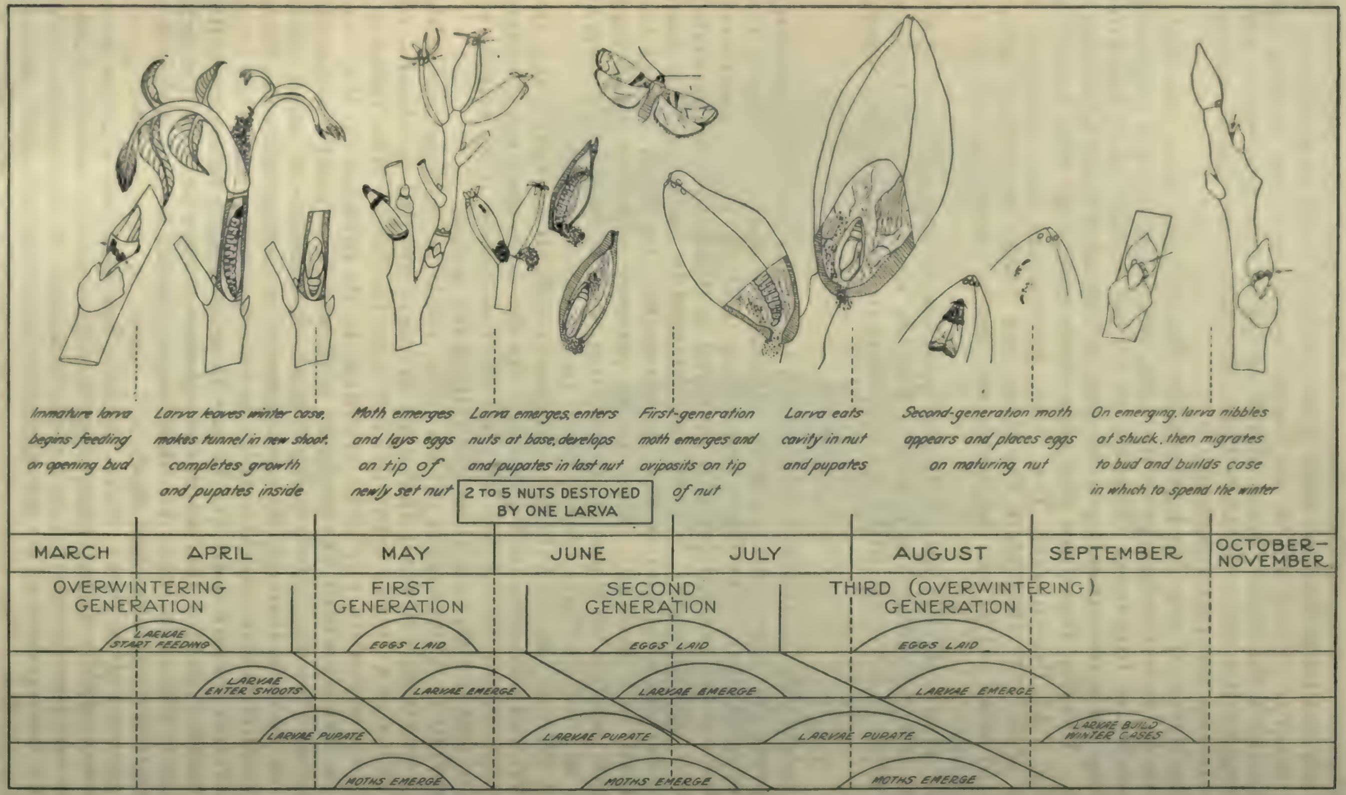
Immature larva begins feeding on opening bud
Larva leaves winter case, makes tunnel in new shoot, completes growth and pupates inside
Moth emerges and lays eggs on tip of newly set nut
Larva emerges, enters nuts at base, develops and pupates in last nut
2 TO 5 NUTS DESTOYED BY ONE LARVA
First-generation moth emerges and oviposits on tip of nut
Larva eats cavity in nut and pupates
Second-generation moth appears and places eggs on maturing nut
On emerging, larva nibbles at shuck, then migrates to bud and builds case in which to spend the winter
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER-NOVEMBER
OVERWINTERING GENERATION
FIRST GENERATION
SECOND GENERATION
THIRD (OVERWINTERING) GENERATION
LARVAE START FEEDING
LARVAE ENTER SHOOTS
LARVAE PUPATE
EGGS LAID
LARVAE EMERGE
MOTHS EMERGE
EGGS LAID
LARVAE EMERGE
LARVAE PUPATE
MOTHS EMERGE
EGGS LAID
LARVAE EMERGE
LARVAE PUPATE
MOTHS EMERGE
LARVAE BUILD WINTER CASES

FIGURE 9.—Seasonal history of the pecan nut case-bearer

stances: Cane sirup, honey, corn sirup, molasses, and vinegar and molasses, to which small quantities of sodium arsenite were added. These were diluted with water at the following strengths: 1 to 10, 1 to 20, and 1 to 50. Three types of containers were used, 2-quart tin buckets, 1-quart Mason jars and 2-quart stew pans. In placing the containers, one was put in the upper part of a tree and one in the lower. These traps were maintained in the trees at various times throughout the period of emergence of moths of the different generations.

The results have been very disappointing, for in no case was a case-bearer moth attracted to the mixtures tried. It is true that many moths of other species, particularly those which breed on grasses and weeds, were caught, but the pecan pests did not come to the traps. Instead, some of the beneficial forms which prey upon various pecan insects were captured.

A series of similar experiments was also tried at Thomasville, Ga., and Monticello, Fla., in which many aromatic chemicals were used as attractants, and up to this time the results have been similar to those obtained with sweetened mixtures. Further investigations along this line are in progress, but until experiments have proved conclusively that this species can be attracted to various mixtures, it is suggested that pecan growers spend their time and money in some other way.

Parasites: A good many growers have no doubt thought at various times of natural enemies in relation to the control of the pecan nut case-bearer. When a pecan grower sees his developing pecans destroyed by the hungry larvae of this pest, he is apt to long for a miracle to remove the plague from his orchard. Sometimes the " miracle " takes place, and many case-bearers never mature to lay their eggs for another generation. Such assistance is frequently given by certain kinds of insects commonly known as parasites. Some of these little friends of the grower live within the bodies of the insects which they attack, called their hosts, where they pass their entire larval existence, while others live externally upon their hosts.

The pecan grower is not without these minute, friendly insects. At Albany, Ga., and Brownwood, Tex., where the Bureau of Entomology maintains laboratories for the investigation of the various pecan insects, a number of parasites of the pecan nut case-bearer have been reared.

The work of all true parasites is rather spasmodic because of the very nature of their existence. Naturally, when they cause a decrease in the numbers of the hosts, the parasites die from lack of food and may be so reduced in numbers that they are not able at a subsequent time to check a rapidly increasing number of the hosts, and a serious infestation may result.

THE HICKORY SHUCK WORM

During the fall a small white larva or worm (fig. 10, right), about three-eighths of an inch in length, may be found mining the shucks of pecan or hickory nuts. This larva is commonly referred to as the hickory or pecan shuck worm (*Laspeyresia caryana* Fitch). The mining or tunneling of the shucks often results in the improper development of the nut kernels and prevents the natural separation of the shucks from the nut shells. Nuts infested by shuck worms are often undersized and later in maturing than those free from this pest. The damage is not restricted entirely to the matured nuts, for in the spring and early summer the larvae destroy the small, green nuts by eating out the interior. Injury of this type is not so noticeable as that caused in the fall, but it should not be minimized, since investigations have shown that it plays no small part in the reduction of the nut crop.

Besides attacking the pecan, this insect feeds upon the nuts of various species of hickory, where the injury it does is similar to that on the pecan, except that the destruction of the small, green nuts seems to be greater. Occasionally the larvae will be found subsisting on the galls formed by certain species of Phylloxera (*Phylloxera caryaecaulis* Fitch, *P. devastatrix* Pergande).

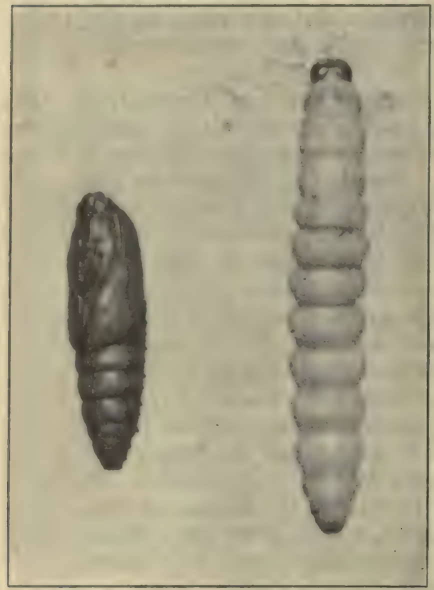

FIGURE 10.—Pupa and larva of the hickory shuck worm: Pupa at left, larva at right. Enlarged 6 diameters.

DESCRIPTION

The shuck worm passes through the same four stages in its development as the pecan nut case-bearer: Egg, larva, pupa, and adult or moth. The moth (fig. 11) is smoky black, mixed with iridescent bluish and purplish tinges, and the forewings have a series of short, yellowish streaks across their front margins. The moths are rather variable in size, but the width across the wings is rarely more than three-fifths of an inch. Because of their protective coloration the moths are seldom noticed in pecan orchards, even by keen observers.

The egg is small, whitish, and more or less oval, and under high magnification its surface is seen to be wrinkled.

The larva upon emerging is a very small, whitish, 16-footed worm. When full grown it is about three-eighths of an inch in length and has a creamy-white body and light-brown head. (Fig. 10, right.)

The pupa (fig. 10, left), which is brownish, is always found within the infested shuck.

SEASONAL HISTORY AND HABITS

In the greater part of the pecan-growing region the hickory shuck worm probably has two generations a year, and in the extreme southern part of the region it apparently has four generations, whereas in the Northern States, where the insect subsists on various species of hickory, there is perhaps only one generation. The moths, which develop from larvae that spend the winter in the fallen pecan or hickory shucks, begin to appear in northern Florida as early as the middle of February. The maximum emergence of moths in that section occurs during the last two weeks of March. Experiments conducted during 1928 and the early part of 1929 have shown that all of the larvae may not transform and emerge during the spring, and larvae may be found in the shucks on the ground and in those buried in the soil during the year. There may be emergence throughout the summer. In some years a few may remain as larvae through a second winter before transforming and emerging.

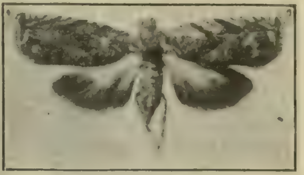

FIGURE 11.—Moth of the hickory shuck worm. Enlarged 2½ diameters

Most of the moths come out before the appearance of the pecan foliage and nuts, and this apparently accounts for the extremely small numbers of first-generation larvae that attack the pecan trees. The development of the foliage and nuts of the pignut (*Hicoria glabra* Mill) and the Mockernut (*H. alba* L.) is much earlier in the spring than that of the pecan, and it seems that the emergence of moths is timed for these host plants. Considerable damage is always done to the very early small hickory nuts by the first-generation larvae, while the very small pecan nuts seem to escape such injury. Some first-generation larvae will be found attacking the tender shoots of pecan, but the apparent reason for the immunity from attack of the recently set pecan nuts is the fact that the emergence of the moths does not coincide very well with the development of the nut.

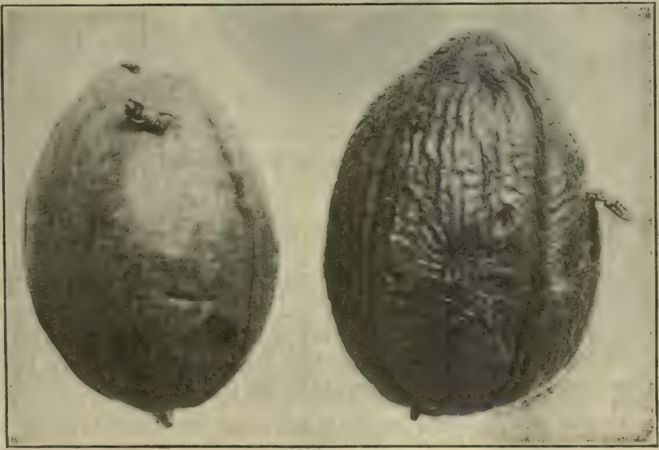

FIGURE 12.—Pupal skins of the hickory shuck worm protruding from shucks of pecan nuts

The moths deposit their eggs on the young nuts or foliage, and during the summer months the period of incubation lasts about five days. Upon emerging the larvae gnaw their way into the nuts by making pinhole entrances and proceed to mine the shucks of the nearly mature nuts, but in early summer the larvae bore into the interior of the green nuts and cause them to drop to the ground. During the spring and summer the larvae usually feed from three to four weeks, and transform to pupae within the green nuts or the shucks of matured nuts.

The length of the pupal period ranges from 9 to 45 days. During the summer months it lasts about 11 days, while most of the pupae from overwintering larvae transform to moths in 18 days, although some few moths do not issue for a considerably longer period. The pupation of the overwintering larvae usually takes place in considerable numbers between the first of February and the middle of April.

Before transforming to the pupal stage the larva prepares a small silk-lined cocoon, and cuts a circular hole to the outside of the shuck, which facilitates the escape of the moth. Just before the emergence of the moth the pupal skin is extended a short distance through the circular cut (fig. 12), the lid of which remains attached to the nut in a sort of trapdoor arrangement.

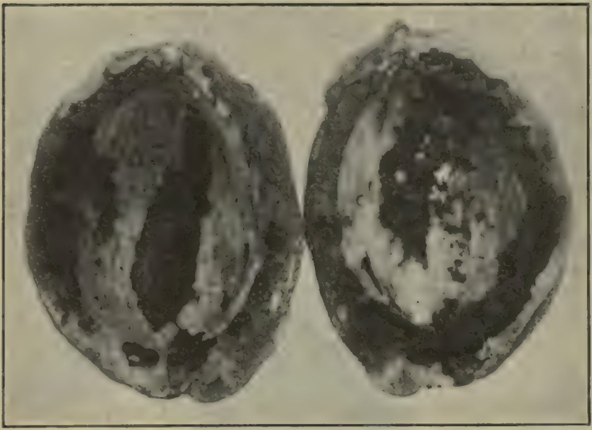

FIGURE 13.—Injury to matured nuts caused by the hickory shuck worm

As stated above, the larvae of the first generation feed for the most part on small hickory nuts, but during the last days of June and through July and August, although continuing their depredations on the hickories, the larvae will be found attacking the green pecan nuts. The first and second generation larvae destroy the interior of the nuts and invariably cause them to drop. The last generation larvae, which attack the nearly matured nuts with hard shells (figs. 13 and 14), feed only on the shucks, in which they mine and attain full growth before the advent of cold weather. They pass the winter as larvae in the shucks on the ground or in shucks that remain on the trees.

CONTROL

There are a number of parasites which attack the shuck worm and aid in the destruction of the species, but usually they are not abundant enough to control the insect.

Since the insects pass the winter as larvae in the shucks, it seems that the best method toward control known is to gather and destroy all shucks; this should be done during harvest or immediately after if possible, and not later than the middle of February. To bring about effective control by this method, the removal of the shucks from the orchard must be very thorough. Some growers prefer harvesting their pecans by means of bamboo poles, whipping the nuts onto sheets stretched beneath the trees. In this way many of the loosened shucks may be collected and gathered into piles in the orchard and burned, and this will help to keep the numbers of the shuck worm down. Plowing under the shucks is not effective, as larvae covered from 2 to 4 inches have been found to come up to the surface of the soil, transform, and emerge as adults. The success of the plowing method depends wholly upon the burying of the pupae within the shucks. Since the larvae leave the buried shucks and the period of pupation extends over such a long time, plowing is of but little value as a control measure.

Hickory trees growing adjacent to pecan orchards will always prove a source of infestation by this pest as well as certain other injurious insects. It would seem, therefore, that the removal of hickory trees from the immediate vicinity of the orchards would be a very good procedure.

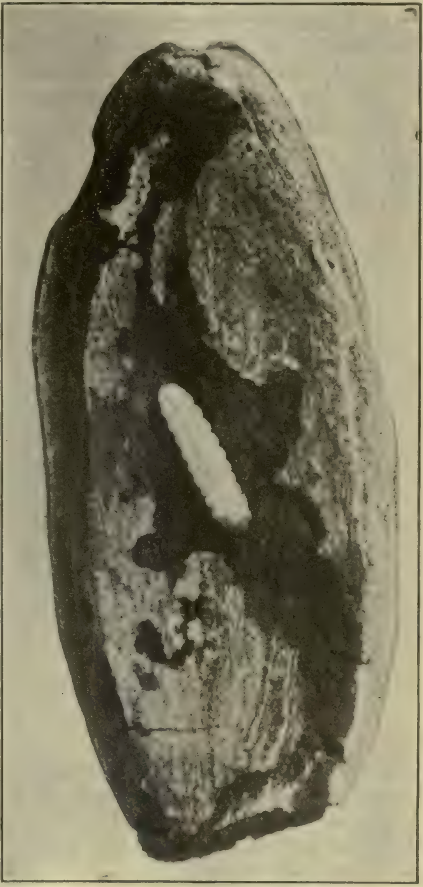

FIGURE 14.—Larva of hickory shuck worm in shuck of nearly matured pecan nut. Enlarged 2 diameters

THE PECAN WEEVIL

The pecan weevil (*Curculio caryae* Horn), sometimes called the hickory nut weevil, is in some sections a serious hindrance to the successful culture of pecans. It has long been encountered in the native pecan groves of Texas and Louisiana and is well known in the cultivated orchards of the more elevated areas in the eastern part of the pecan belt. In Georgia and Alabama injury is largely confined to the piedmont region, although the insect is known to occur in pecans in the extreme southern portions of those States. Like many other insects, the pecan weevil causes much more damage in some years than in others, but in its range this pest can be counted on to bring considerable loss to pecan growers.

Schley and Stuart pecans are the most subject to attack, evidently because these are among the earliest varieties to form kernels. The weevil also breeds in hickories over the pecan belt and occurs as far north as New York on some species. This affinity for hickories makes the problem more difficult for pecan growers, as there is a direct relation between the abundance of hickory and wild pecan and the severity of weevil infestation of cultivated pecans in the same locality.

NATURE OF INJURY

The first injury of the season occurs when adult weevils appear in the trees and puncture the nuts before the latter have passed the "water stage," that is, before the kernel has formed within the nuts. Injury by weevils at this time causes the nuts to shrivel, turn dark inside and out, and usually fall in a few days. This darkening of the nuts has been called "black pit," a malformation which is also caused by certain other insects and probably by mechanical injury such as the beating of twigs against nuts in a high wind. A much better known injury by the weevil is the destruction of nuts in the fall by grubs or worms which are the young of the weevil. Activity of this insect in an orchard is disclosed by holes in the mature nuts (fig. 15) made by the emergence of full-grown larvae. The hole is round and about one-eighth of an inch in diameter. Infested nuts can also be distinguished before the larvae issue from the fact that the shuck fails to separate from the shell at the time when normal nuts are ripening.

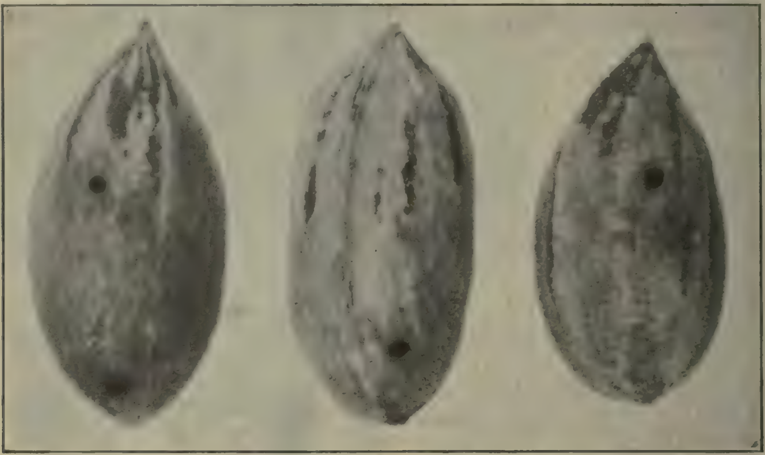

FIGURE 15.—Exit holes of larvae of the pecan weevil

DESCRIPTION

The adult of the insect is a dark-brown weevil with pale-brown or gray scales; it has awkward legs and an extremely long slender beak. (Fig. 16.) The beak of the female measures one-half of an inch, or about one-eighth of an inch longer than the body; that of the male is shorter than the body.

The egg, which is capsule shaped or irregular in form, is one thirty-fifth of an inch in length. It is smooth and clear. The immature larva is white. The mature larva (fig. 17) is a fat yellowish grub with a small reddish-brown head and without legs. It is three-eighths to one-half of an inch long. The pupa is white and, having no covering, shows the developing appendages of the adult into which it transforms.

SEASONAL HISTORY

Adult weevils emerge from the ground during the summer, and both males and females feed by puncturing immature pecans and hickory nuts and drawing juices from the center. In 1928 the weevils emerged near Barnesville, Ga., from July 12 to September 15. The height of emergence came after heavy rains in the middle of August. Emergence during 1927 occurred somewhat earlier. Mating and oviposition begin in the latter part of August or first of September and continue about one month. Though punctures are made in nuts as soon as weevils start emerging, eggs are not laid until nuts can be found with well-developed kernels. The shells at this time are nearly hardened. When laying eggs, the female first drills a hole (fig. 18) through the shuck and shell with her long beak, at the end of which are two minute teeth. From this center she drills holes into the kernel in different directions, some going deep into it, some turning upward to the shell.

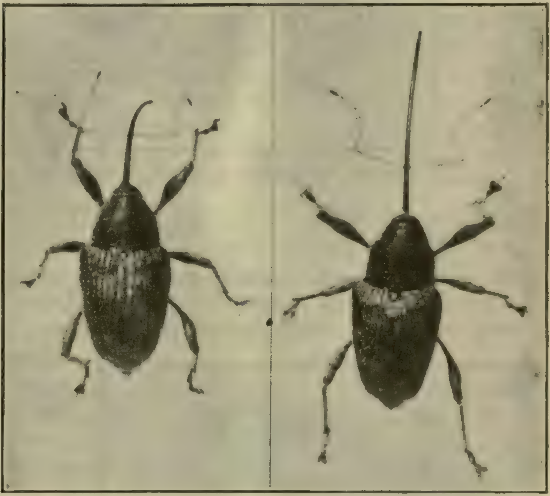

FIGURE 16.—Adults of the pecan weevil: Male at left, female at right. Enlarged 2½ diameters

Hickory nuts have been found with all the eggs laid in little pockets in the outer skin of the kernel in a ring around the one puncture which passed through the shell. Eggs may be placed in the solid part of the kernel or in the fissure or narrow open space in the very center of the nut. The eggs are laid one at a time in the puncture and pushed to their places, probably with the aid of the beak. Two to six eggs have been found laid through one puncture. Rarely is more than one puncture made in a nut for egg-laying, and apparently weevils shun nuts which have already been punctured. The eggs hatch in a week, and the grubs find a rich supply of food at hand and become full grown in one month. Thereupon they leave the nuts by cutting a hole through the shell and shuck and immediately enter the soil under the tree. The larvae penetrate to a depth of 1 to 9 inches and form regular cells by pressing back the surrounding earth. Apparently a heavy compact soil is essential to the formation of these cells. Larvae go somewhat deeper in cultivated than in uncultivated soils. In a hickory forest they go to a depth of 1 to 5 inches or an average of 3 inches, while in a cultivated pecan orchard they go as deep as 9 inches, though most of them are found about 6 inches below the surface.

The mature larvae issue from nuts beginning the latter part of September through November and have been observed to emerge as late as January. Most of them leave the nuts during October. Larvae live in their underground cells without feeding. Pupation takes place in the bare cell the first or second fall after leaving the nut. In about one month the pupa changes to adult and the latter forces its way up through the ground the following summer. Thus there is an overlapping of generations. Some weevils emerge the second year and some the third year after entering the ground as grubs. Probably most of them require three seasons for development.

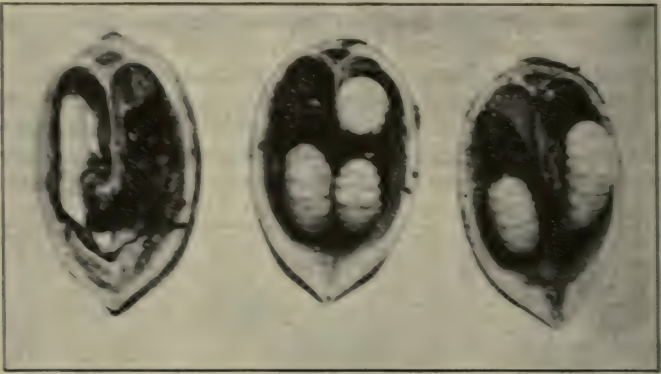

FIGURE 17.—Grubs or larvae of the pecan weevil within the nuts

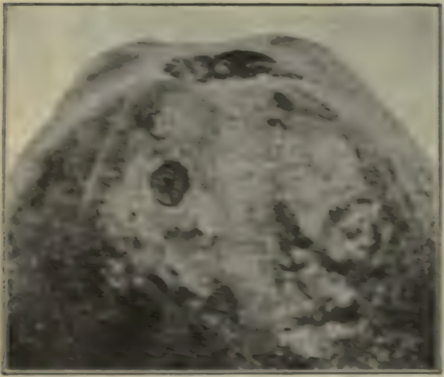

FIGURE 18.—Egg puncture of the pecan weevil in pecan shuck. Enlarged 3 diameters

CONTROL

No adequate means for control of the pecan weevil has been perfected, but a number of measures may be suggested to curb its destructiveness. The first is the elimination of hickories where this is practicable. Do not set out an orchard in the vicinity (say one-half mile) of hickory forests, as these breed hosts of recruits to infest pecan nuts.

Another measure is to gather nuts from trees before the larvae have had time to leave them and destroy these larvae before they reach the soil to burrow and complete their development. This requires making an early harvest. The latter part of September examine trees of susceptible varieties, Schley and Stuart, for weevil infestation. As stated before, on all nuts which have been attacked, the shucks fail to open. Cut open some of these and see if they contain grubs. Some shucks fail to open from other causes, as shuck-worm damage, underdevelopment, and early frosts, so the only certain way to make diagnosis is to find the grubs. Some trees will be found much more heavily infested than others, even of the same variety and on adjoining rows, and accordingly every tree should be examined. With severely infested trees the most satisfactory procedure is to thresh off all nuts before the grubs begin to issue and place them in tight-bottomed containers to keep the grubs from reaching the ground. Later, after the period of emergence is ended, the non-infested nuts can be graded out. This early gathering will entail considerable extra work, as the green nuts are not readily knocked from the trees, but if nothing is done until the regular time for harvest it will be found that practically all larvae have emerged from the nuts and gained access to the soil.

Thorough cultivation of pecan orchards doubtless aids in weevil control. Some stages of the weevil can be destroyed by exposing them to the weather and their natural enemies. The grubs are little affected by cultivation, for when turned to the surface they at once burrow again and make new cells. The pupae and adults, however, are helpless when taken from their cells and can not dig below the surface. Deep plowing, at least 7 inches in clay or clay loam, in the winter or spring will help to kill the adults which would normally emerge during the ensuing summer. Hogs and chickens, if confined to the orchard, will destroy many insects turned up by the plow.

THE SOUTHERN GREEN STINKBUG AND OTHER PLANT BUGS

BLACK PIT AND KERNEL SPOT

Black pit and kernel spot of the pecan are manifestations brought about by the feeding of sucking insects upon the immature nut. They are well known over the pecan belt and, though not considered major problems, occasionally become quite serious to an individual grower. They are found to recur irregularly in restricted sections, being abundant one year and practically absent the following. Both of these troubles were first thought to be caused by fungi, but it has been shown that they are caused by the feeding of the southern green stinkbug (*Nezara viridula* L.) (figs. 19 and 20) and some closely related species.[3] (Fig. 21.)

Black pit is a discoloration of the interior of the green pecan. The affected nuts always drop prematurely. Much of the midsummer drop often attributed to other causes is probably due to black pit caused by the feeding of these sucking insects. The only outside evidence noticeable before the nuts fall is a brown stain on some of the nuts caused by the juice coming through the small hole made by the puncture of the insect. The first sign of damage to attract the pecan grower's attention is the dropping of the nuts in early summer. The affected nuts sometimes show brown or black spots on the shuck; these often spread over the entire surface soon after the nuts drop.

These sucking insects commence feeding on the nuts when quite small, probably the middle or latter part of June, and continue until the nuts are practically mature. However, the punctures made after the nuts are past the water stage do not produce black pit but instead a condition known as kernel spot.

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[3] *Leptoglossus phyllopus* L., the leaf-footed bug; *L. oppositus* Say, the northern leaf-footed bug; and *Euschistus euchistoides* Voll.

Pecan kernel spot[4] consists of dark-brown or black spots of variable size on the kernels of the nuts. (Fig. 22.) Upon the central portion of each spot is found a small pimplelike structure, which marks the entrance of the insect's beak. A magnified cross section of the center of a spot shows rupturing of the epidermal cells and those cells lying immediately beneath, a condition which seems to be caused by the extraction of the oil and other substances from that portion of the kernel. An affected kernel may have several spots, varying in diameter from one-sixteenth to three-sixteenths of an inch. Although the surface of the spot is dark, the internal part is whitish. The spots are pithy and porous and are decidedly bitter, but this bitter taste does not seem to be imparted to the unaffected portion of the kernel. This injury can not be detected until after removing the shells, as there are no discernable signs of insect injury on the outside of the shell of fully-matured nuts. On immature nuts, however, the punctures may be seen if examined closely, as the shell is whitish until the nut enters the ripening or maturing stage. Usually there is also a slight depression or pit in the shuck at the point of entrance of the insect's beak.

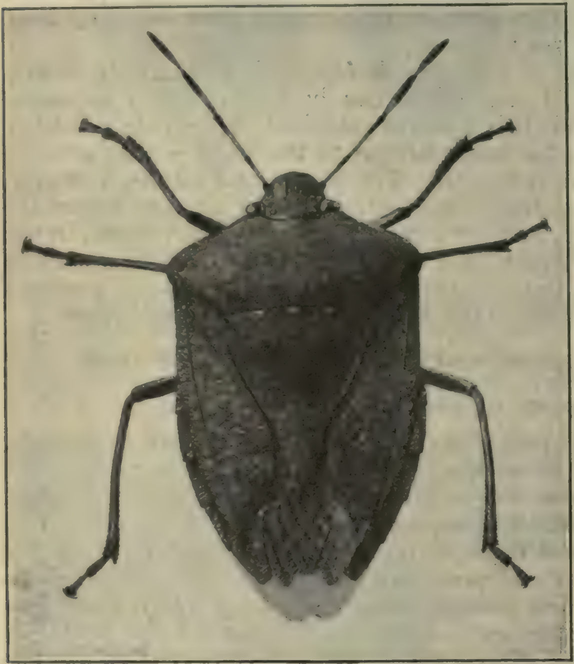

FIGURE 19 — Southern green stinkbug. Enlarged 4½ diameters

DESCRIPTION AND LIFE HISTORY OF THE SOUTHERN GREEN STINKBUG

As the habits of the various species of plant bugs which cause black pit and kernel spot are quite similar, only the southern green stinkbug will be described. The southern green stinkbug is usually of a light-green color, with the upper surface somewhat darker than the under surface. Adults collected during the colder months of the year, however, are usually much darker, with a purplish or pinkish tinge. The adult is shield shaped, which is the characteristic form

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[4] For a more complete account of pecan kernel spot see U. S. Department of Agriculture Bulletin 1102, Kernel Spot of the Pecan and Its Cause.

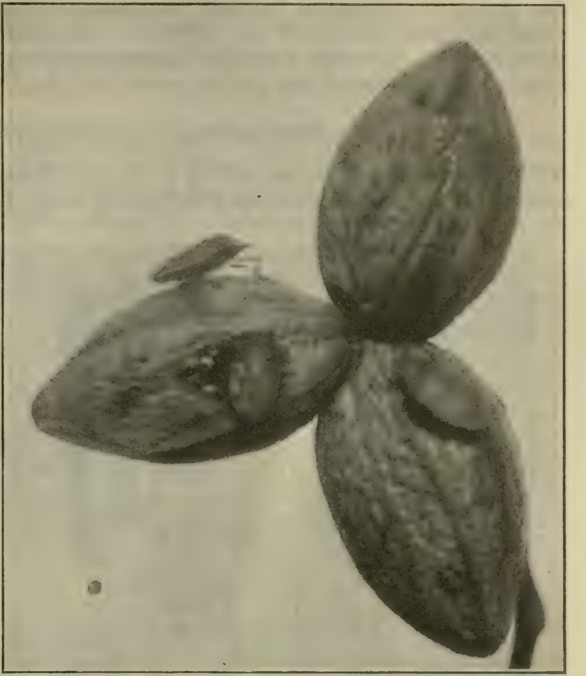

FIGURE 20.—Southern green stinkbug on pecan nuts of the Curtis variety

of the members of the stinkbug family. The upper surface of the body is slightly convex, while the lower surface may be termed strongly convex. It measures about one-half of an inch in length. When disturbed or handled, the adults give off a strong disagreeable odor, and on account of this habit the name "stinkbug" is applied to this species as well as to many closely related forms.

The southern green stinkbug passes the winter in the adult stage, often leaving its winter quarters during periods of mild weather. Egg laying does not begin until early in April and may continue until the middle of November. The eggs (fig. 23) are laid in clusters on the underside of the foliage, and during the summer months they hatch in five or six days. The number of eggs in a cluster has ranged from 36 to 116. The young bugs molt five

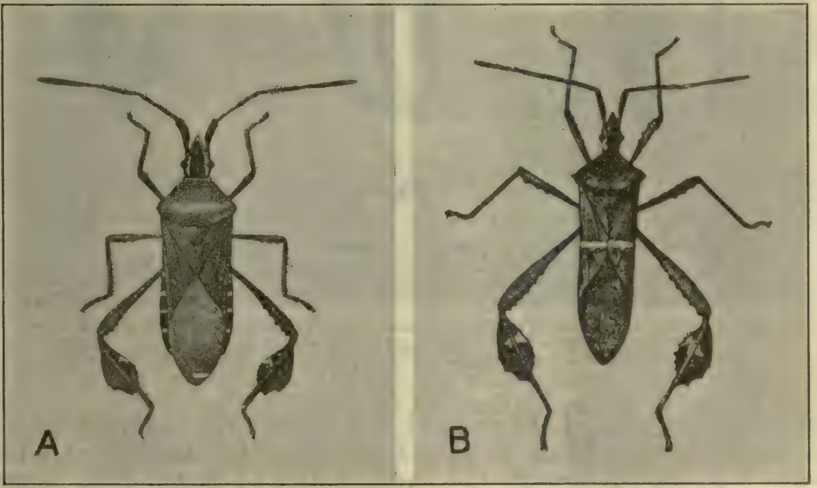

FIGURE 21.—A, Leaf-footed bug; B, northern leaf-footed bug. Enlarged 2 diameters

times before attaining full growth, and with each molt they take on a marked variation in color pattern. It is very probable that this species may develop four full generations annually in the extreme southern portion of the pecan belt.

FOOD PLANTS AND FEEDING HABITS

The southern green stinkbug is one of the most widely distributed insects known to science and infests a wide variety of plants. It is found in nearly all of the tropical and subtropical countries of the world, extending well up into the temperate regions; in the United States it is spread through the southern tier of States from South Carolina to California. The list of recorded hosts covers such diversified plants as corn and artichoke, sandspur and sunflower. There are included a number of trees, though the species is primarily herb-

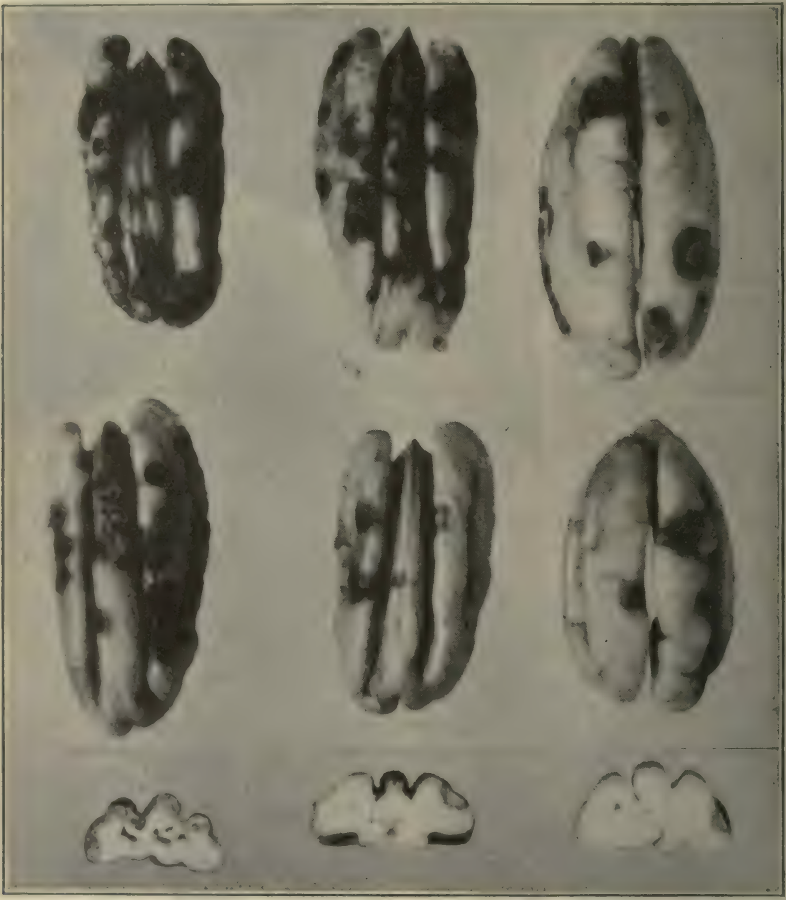

FIGURE 22.—Kernel spots on Schley pecans. The upper and central views show the location of the spots on the ridges and edges of the pecan halves. The three lower views of kernels, cut through the spots, show the depth and extent of the injury

infesting and is generally known as a pest of truck and cover crops. Members of the mustard family, including collards, mustard, and radish, and members of the pea family, including beggarweed, rattlebox, coffee weed, and cowpea, are the most attractive to this insect.

Like all others of the large group of insects called plant bugs, the southern green stinkbug feeds by piercing a plant with its strong sharp beak and sucking the plant juice. It is unable to take food from the surface and furthermore is unable to eat any but liquid food.

Two other points about the feeding of this insect are important. The bug distinctly prefers growing tips and the soft pulp of an immature seed pod or fruit to the harder parts of a plant. Accordingly many fruits in the tender stage may be attacked.

The second point is that of the number of plants on which the species feeds only a few are breeding hosts, that is, plants on which eggs are laid and the young develop. Other plants, such as the pecan, are attacked only by the adults which fly from these breeding hosts.

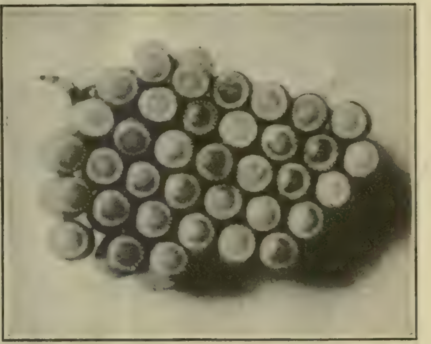

FIGURE 23.—Egg cluster of southern green stinkbug viewed from above. Enlarged 6 diameters

CONTROL

Natural factors, including low temperatures and insect enemies, help in keeping the southern green stinkbug in check. The pecan grower must not rely on these factors, however, to protect pecans from kernel spot or black pit. The growers of truck crops may resort to contact insecticides, hand picking, and trap crops, but these are not readily applicable to conditions of pecan culture. To the pecan grower is suggested the proper use of cover and intercrops and the sanitation of orchards.

Clean cultivation, a practice which would aid in the control of the stinkbug, can not be recommended in pecan orchards, because the soils need organic matter which may be maintained by the use of green cover crops. Cowpeas have long been commonly used to provide the much needed humus; but the cowpea is a favored host of the stinkbug, and the worst outbreaks of kernel spot have been reported from pecan orchards planted to cowpeas or adjacent to large fields of cowpeas that have been cut for hay. The soybean is unsafe to use for the same reason, and neither should be planted in a bearing orchard. The bugs fly from the hardening bean pods to the trees, where they feed on the nuts. Fortunately the velvetbean is known to be practically free from the attacks of this insect and therefore can be safely used among pecans.

Many of the hibernating adults can be killed by thorough sanitation in winter. This applies to certain other pests also and is good orchard practice. Fence rows particularly should be cleared. Burn plant refuse such as corn and cotton stalks, pecan shucks, nuts and leaves, dead weeds, and grass in which the insects hibernate. Late in the winter destroy mulleins, wild mustard, and any other green plants that harbor the early feeders. Kernel spot and black pit may be prevented by eliminating from pecan orchards and their vicinity the plants in which the bugs breed.

Since the species of plant bugs closely related to the southern green stinkbug, which likewise cause black pit and kernel spot, have breeding habits which correspond to some extent, the control measures which apply to the southern green stinkbug may be employed against them. It may be added that various plants, such as jimson weed, yucca, basketflower, and thistle, have been found to serve as breeding hosts of these plant bugs, and wherever they are found growing efforts should be made to eliminate them from the orchard.

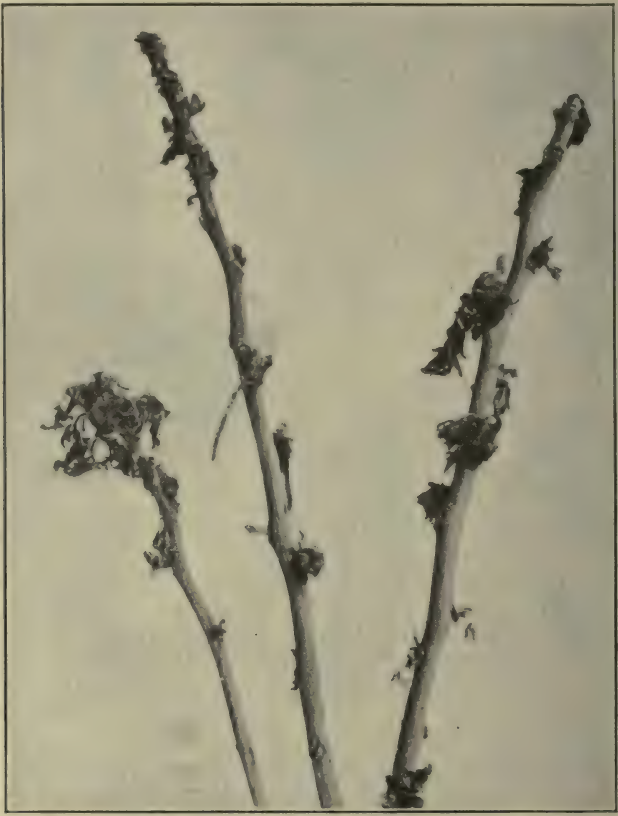

FIGURE 24.—Injury to young pecan buds in spring caused by larvae of the pecan leaf case-bearer

INSECTS INJURING THE FOLIAGE AND SHOOTS

THE PECAN LEAF CASE-BEARER

The pecan case-bearer (*Acrobasis palliolella* Rag., formerly erroneously called *Acrobasis nebulella* Riley), which is found in very injurious numbers in orchards in the southern portion of the pecan-growing area, extending from Florida to Texas, is one of the worst pests affecting the culture of pecans. Although this insect has been reported definitely from practically all of the Southern States in which pecans are grown, it probably ranks as a serious pest only in Florida and the southern parts of Georgia, Alabama, Mississippi, Louisiana, and Texas.

This insect occurs also in some of the Northern and Middle Western States where the pecan is not grown, and here it subsists on various hickories. Generally speaking, the pecan leaf case-bearer is distributed over approximately the same territory as are its preferred hosts, namely, the pecan and hickories. Evidently certain climatic factors limit the destructiveness of this species, and because of these conditions it has not been able, apparently, to become a pest in the northern part of the pecan-growing area.

The most serious damage by the leaf case-bearer is done during the early spring and is inflicted by the worms, which emerge from their winter cases and feed voraciously upon the unfolding buds and leaves. (Fig. 24.) These worms or larvae are small and dark brown at this time, but soon change to dark green as they feed upon the foliage. Upon leaving the winter cases the larvae enter the buds at the tips and partake of their first meal after having spent several months in hibernation. On badly infested trees the buds and tender leaves suffer serious injury (fig. 25), and often the foliage is consumed by the larvae as fast as it puts forth. It is not unusual to see pecan trees kept in a defoliated condition for weeks during the spring by the attacks of this insect. (Fig. 26.)

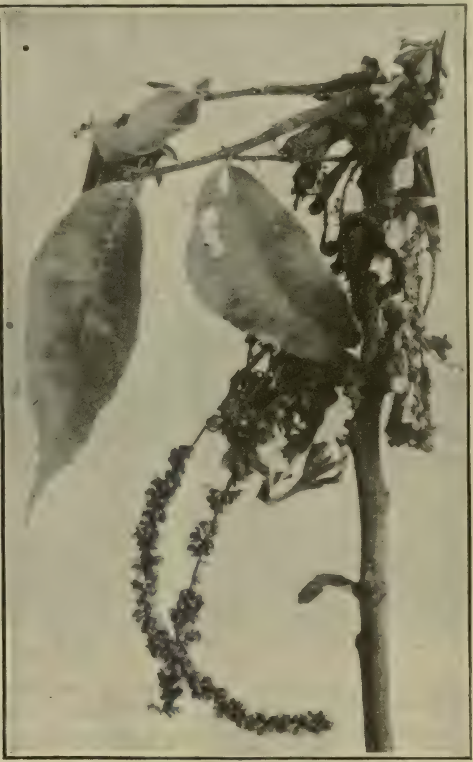
FIGURE 25.—Injury to pecan foliage and flowers by larvae of the pecan leaf case-bearer

Since the larvae are not at all discriminating in their feeding habits, devouring the blossom buds as well as the leaf buds, they are capable of greatly reducing the yields of nuts for the current season, besides leaving the trees in a more or less weakened condition.

DESCRIPTION

As is the case with all moths, the pecan leaf case-bearer has four distinct stages; namely, egg, larva, pupa, and adult or moth. The moth (fig. 27) measures about two-thirds of an inch across the expanded wings and presents a wide variation in color. The head, thorax, and base of forewings and legs are snow white in the males, but in the females these parts are dusky gray. The abdomen is whitish, marked with brown. The outer two-thirds of the forewing is gray, with blackish blotches or spots, which are somewhat variable, and not far from the base of the forewing is a reddish-brown stain.

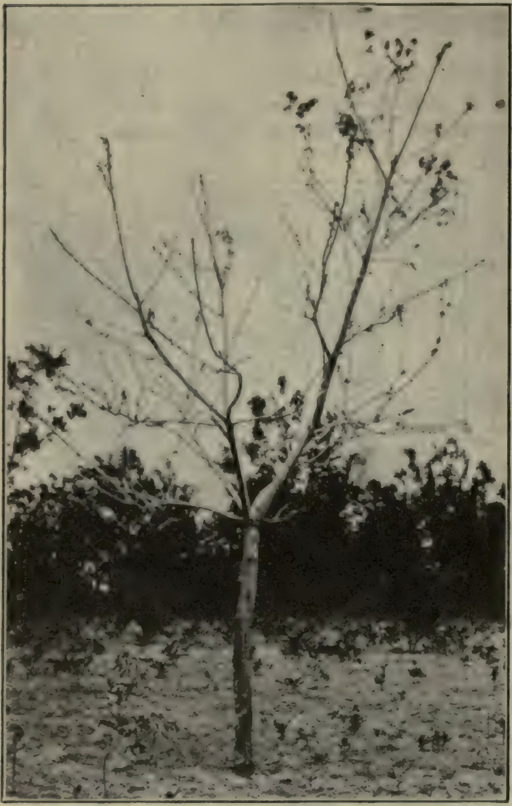

FIGURE 26.—Pecan tree defoliated by the pecan leaf case-bearer

The egg (fig. 28) is oval and white, with a slight greenish tinge.

The larva (fig. 29), which is the form that inflicts the injury to buds and foliage, is a dark-green, cylindrical worm measuring a little over one-half inch in length when fully grown. The head is rounded, shiny dark brown or black. The general color of the body is a very dark green, excepting the part immediately back of the head, which is somewhat lighter. The skin is much wrinkled into folds, and the entire body is sparsely covered with fine long hairs.

The pupa (fig. 30), to which the full-grown larva changes, is of the usual form and without conspicuous markings. When first formed it is fairly dark brown, with a tinge of olive green, but later it turns to a deep, shiny, mahogany brown. The pupa is formed within the larval case.

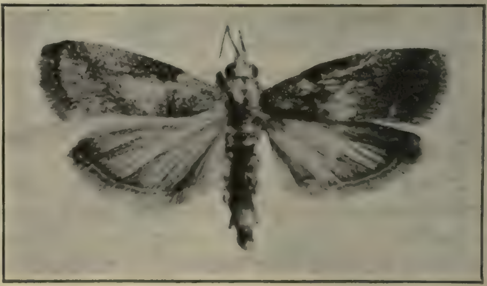

FIGURE 27.—Moth of the pecan leaf case-bearer. Enlarged 3 diameters

SEASONAL HISTORY AND HABITS

Only one generation of the pecan leaf case-bearer develops during the course of a year, but more or less variation exists in the development of the different stages. For instance, from material under observation during the season of 1913 it was found that the moths, numbering in all 269, emerged from May 9 to July 12. In 1914 the dates of issuance for 385 moths ran from May 15 to August 5, and in 1915 the dates at which the 591 moths emerged were from May 22 to July 23. For the three years the time of greatest or maximum emergence was the same, being the latter half of June. Because of the wide variation in moth emergence a corresponding variation occurs also in the time of egg laying. Eggs are deposited always on the underside of the leaves and usually near the junction of a vein with the midrib. (Fig. 28.) The egg stage has been found to last from six to nine days, the average being seven days. The eggs hatch from about the middle of May until the latter part of July or the first few days in August, depending more or less upon weather conditions. When the young larvae gnaw their way out of the eggshells they commence feeding upon the portion of the leaf where eggs were laid.

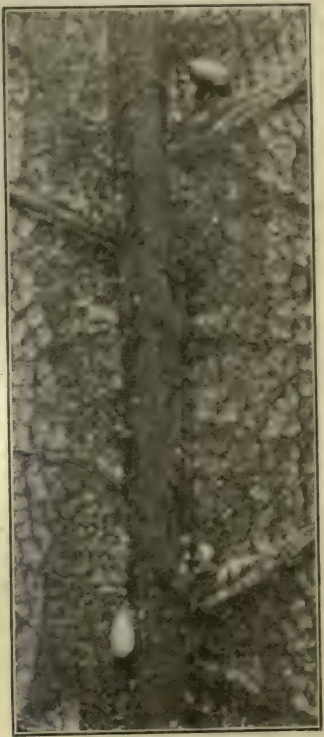

FIGURE 28.—Eggs of the pecan leaf case-bearer along midrib on lower surface of a pecan leaf. Enlarged 12 diameters

Throughout the summer and early fall the larvae feed very sparingly upon the foliage, and as they extend their feeding area they enlarge their little winding cases (fig. 31), which afford very good protection for them. Although they may feed for nearly three months, or even longer in some instances, they rarely attain a length greater than one-sixteenth of an inch by fall. During the latter part of September, or shortly before the leaves begin to drop, the little larvae begin to seek winter quarters around the buds, and here they construct small, compactly woven, oval cases known as hibernacula (fig. 32), and by the middle of October practically all larvae have left the foliage and are to be found snugly protected in these cases. They remain in hibernation until the latter part of March or the first

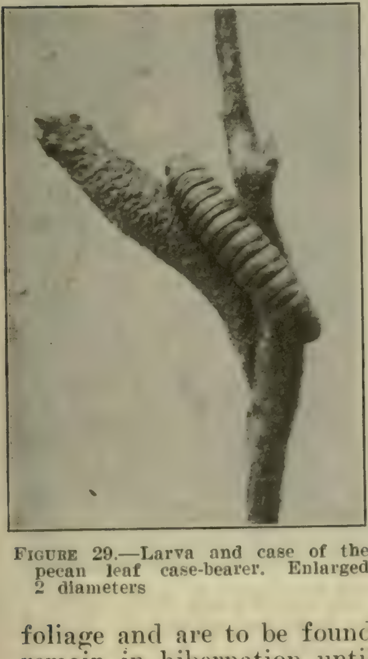

FIGURE 29.—Larva and case of the pecan leaf case-bearer. Enlarged 2 diameters

part of April, at which time the buds on pecan trees usually begin to open.

Just as the buds are opening the larvae emerge from their winter cases and attack the unfolding leaves. Their pernicious feeding habits at this time result in serious injury to the foliage and in greatly reducing the yield of nuts. The larvae feed voraciously during the spring and some of them reach full growth as early as the last days of April, but the majority do not attain full growth until May or early in June.

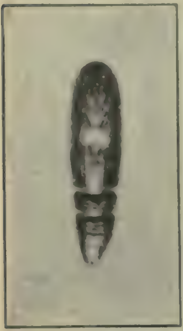

FIGURE 30.—Pupa of the pecan leaf case-bearer. Enlarged 2½ diameters.

The larvae always transform to pupae within their cases (fig. 33), and just before pupating they spin a flimsy layer of silk over the free ends of their cases. The pupal period has been found to range from 16 to 23 days, the average being a trifle over 17 days. The first adults make their appearance about the middle of May and moths continue to come forth until the first week in August. Thus the life cycle of this insect, which it will be seen covers the entire year, is completed.

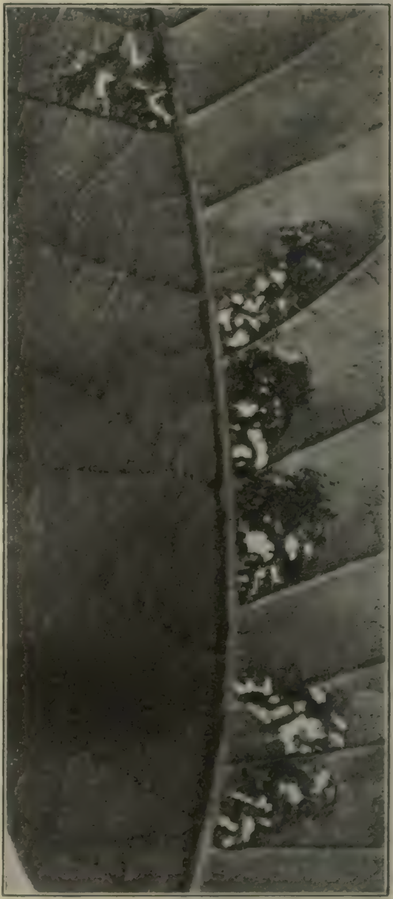

FIGURE 31.—Injury to lower surface of pecan leaf by newly hatched larvae of the pecan leaf case-bearer. Enlarged 2½ diameters

CONTROL

Although the pecan leaf case-bearer is attacked by a number of parasitic insects, it has been found that the parasitic or other natural enemies can not be relied upon to control this pest, but artificial measures of control can be instituted successfully and practically to check its ravages. A mite (*Pediculoides ventricosus* Newp.) often destroys many larvae in the spring during dry seasons. Three species of birds—the blue jay, the mocking bird, and the orchard oriole—have been observed feeding upon the larvae.

Investigations have shown that the pecan leaf case-bearer can be controlled by spraying with calcium arsenate. This should be used at the rate of 1 pound to 50 gallons of 3–4–50 Bordeaux mixture.

Under no circumstances should calcium arsenate be used without Bordeaux mixture, as more or less serious injury to the foliage or nuts is likely to result. Arsenical injury has not been noticed on pecan trees where calcium arsenate is used in combination with Bordeaux mixture, as used in the last application for pecan scab on scab-susceptible varieties or when Bordeaux mixture is used on pecan trees against leaf blotch or brown leaf spot.

Only one thorough spraying is necessary to control this pest. This should be applied at the time of the last Bordeaux application for pecan scab, leaf blotch, or brown leaf spot about July 15.

In spraying it should be borne in mind that only the larvae that have fed on the poisoned foliage will be killed. Growers should realize the importance of spraying at the proper time and apply the poison thoroughly to all parts of the foliage, especially the underside, upon which the larvae are feeding.

Dusting for the control of the pecan leaf case-bearer is not recommended, as very unsatisfactory results have been obtained in experimental work in the use of dust mixtures.

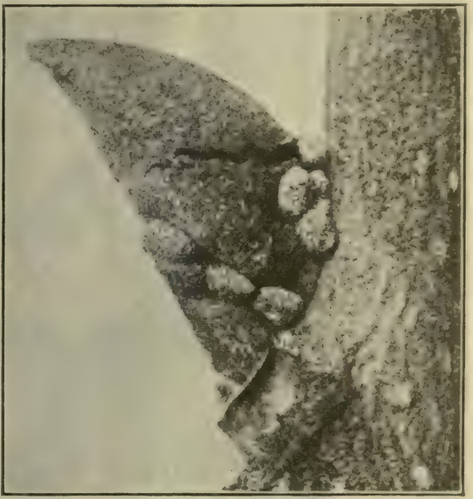

FIGURE 32.—Winter cases of pecan leaf case-bearer around pecan bud. Enlarged 7 diameters

THE PECAN CIGAR CASE-BEARER

The pecan cigar case-bearer (*Coleophora caryaefoliella* Clem.) is usually considered a pest of only minor importance, but reports have been received of its occurrence in injurious numbers in pecan orchards during the spring months and of the infliction of serious damage to the buds and foliage. (Fig. 34.) This insect does not confine its attacks to the pecan, as it feeds upon the various species of hickory and the black walnut. The pecan cigar case-bearer is distributed over a wide range of country, extending from Florida to the extreme border of Texas and as far north as New Hampshire. When the buds of the pecan are opening, or just after they have begun to unfold, the hibernating larvae become active and attack them, continuing their feeding operations on the foliage (fig. 35) until about the middle of May (in Florida), when they become full grown and transform to pupae within the lateral cases. (Fig. 36, *b* and *c*.) The pupal period lasts about two weeks, and during June the moths (fig. 36, *a*) appear in numbers on the pecan trees.

The eggs are deposited on the foliage and hatch within a few days. Upon emerging the larvae feed first as leaf miners, but later in the season they construct the small cases, in which they feed upon the leaves until a short time before the foliage drops in the fall. The larvae then migrate to the twigs or larger limbs or trunks, where they attach their cases and spend the winter.

CONTROL

This species is rarely abundant enough in orchards to call for special treatment. In pecan orchards in which spraying is directed against the more injurious pests the pecan cigar case-bearer rarely will be a source of trouble, as the larvae of this and the other species are killed by the same treatments. If this insect becomes abundant in the spring, calcium arsenate should be used at the rate of 1 pound to each 50 gallons of 3-4-50 Bordeaux mixture as applied for the first scab application.

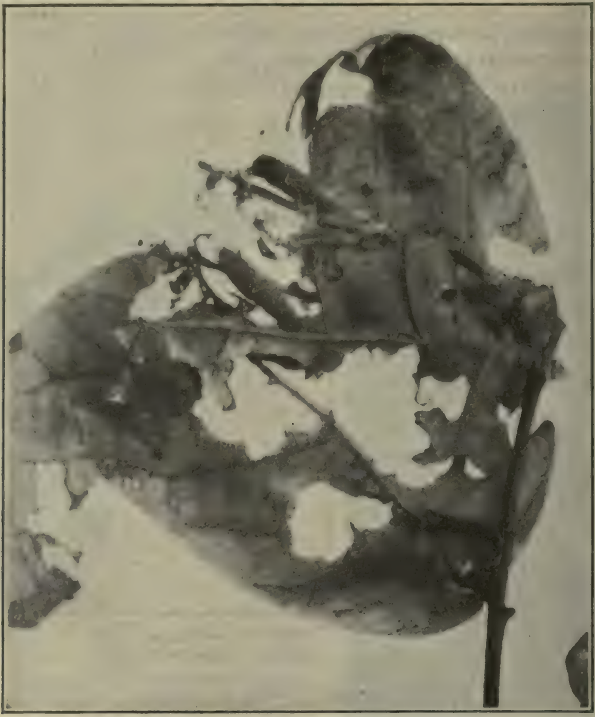

FIGURE 33.—Larvae of the pecan leaf case-bearer in their cases and injury done to pecan leaflets

THE PECAN BUD MOTH

The pecan bud moth (*Gretchena bolliana* Sling.) at times becomes so abundant that the damage caused by the larvae feeding upon the terminal buds of pecan nursery stock entails considerable loss to nurserymen. This insect evidently occurs throughout the pecan-growing region, as reports of damage have been received from most of the Southern States. Besides feeding upon the pecan, it has been recorded doubtfully on various hickories and the black walnut.

DESCRIPTION

The moth is gray, mottled with blackish-brown patches and streaks, and the expanse of the wings is just a little more than half an inch. The blackish-brown patches on the forewings are arranged in a zigzag fashion from the base of the wing to the tip. The hind wings are without markings and are dusky gray, with the outer margin somewhat darker. The moths are very active, but are often found resting on the tree trunks. When disturbed the moth will fly in a jerky manner for a short distance and then suddenly wheel about to return to the tree trunk that it just left.

The eggs (fig. 37) are small, oval, whitish, and iridescent in some lights. When the trees are in foliage the eggs are laid upon either the upper or lower surface of the leaves, but before the buds push forth in spring the eggs are often found deposited on the twigs.

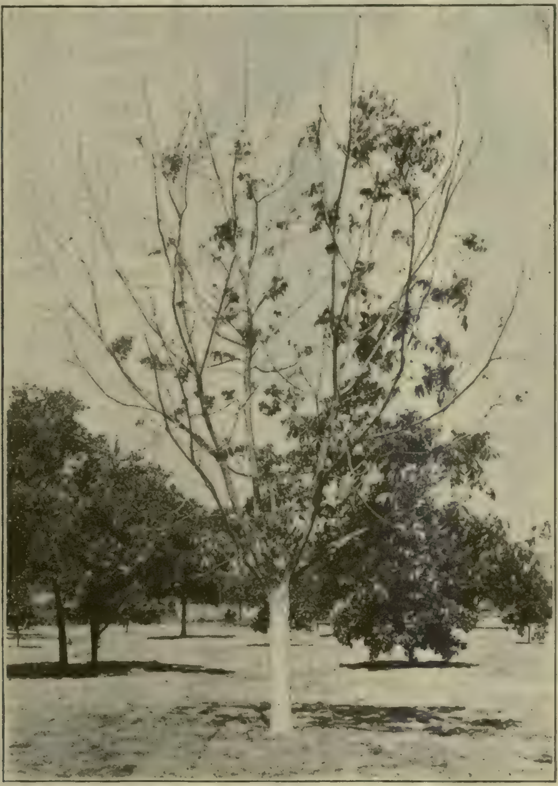

FIGURE 34.—Pecan tree almost defoliated by the pecan cigar case-bearer

The full-grown larva (fig. 38, right) is about five-eighths of an inch in length. The body, which is sparsely covered with fine hairs, is yellowish green, and through its semitransparent skin can be seen the brownish contents of the alimentary canal. The head and cervical shield, or neck, are shiny dark brown in color in full-grown larvae: but on very young larvae they are jet black.

The pupa (fig. 38, left) is light brown and varies somewhat in size, but is rarely more than one-third of an inch long. The pupae

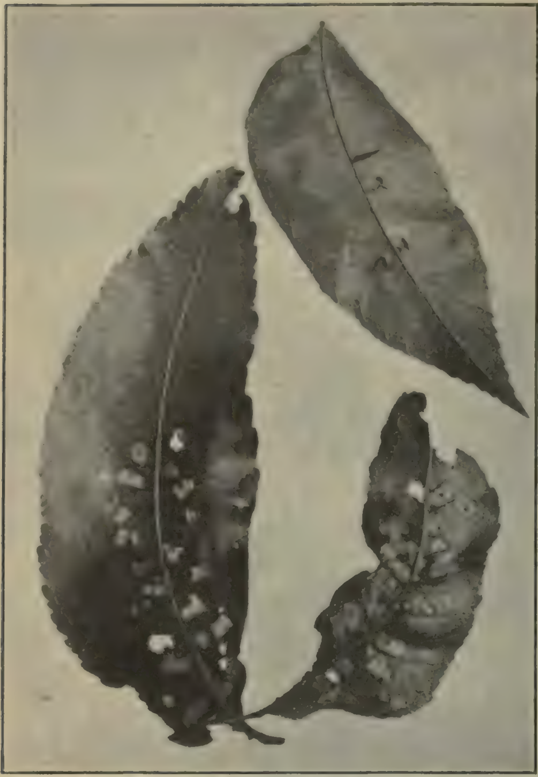

FIGURE 35.—Pecan leaves injured by larvae of the pecan cigar case-bearer

usually are formed in rolled-up leaves or infested buds, but occasionally they can be found under bark scales or at the crown of the tree.

SEASONAL HISTORY

The number of generations a year varies somewhat in different sections. In the extreme southern portion of its range, five or six occur during the course of a season. The pecan bud moth passes the winter in the adult stage. As soon as the buds on the pecan trees begin to open, the moths commence to lay eggs, usually on the branches near the buds, but after the foliage appears the eggs are laid invariably on the upper surface of the leaves. The eggs hatch in from 3 to 6 days, depending upon the temperature. The larvae feed from 21 to 29 days, the average being about 25 days. The pupal stage lasts from 8 to 13 days, with an average of 10 days.

CONTROL

Ordinarily the bud moth does not occur in sufficient numbers to be ranked as a serious pest in pecan culture. In bearing orchards it is rarely troublesome, but during some seasons it is responsible for considerable damage to nursery trees. This species is primarily a bud feeder, and in attacking the terminal buds on the young pecan trees it causes a stunted growth as well as excessive branching. This feature is

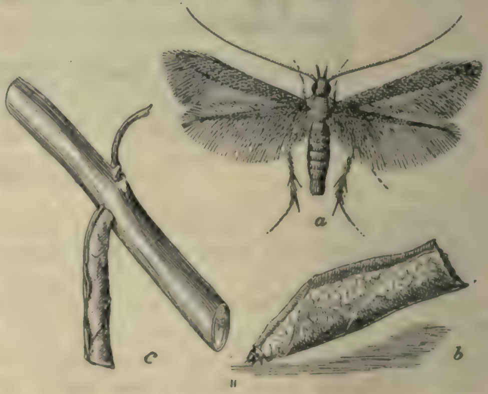

FIGURE 36.—The pecan cigar case-bearer: *a*, Moth, enlarged 8 diameters; *b*, larva in case, enlarged 6 diameters; *c*, larva in case attached to twig, enlarged 4 diameters

especially objectionable, from the nurseryman's point of view, since pecan nursery stock is sold according to height. It has been observed that vigorously growing trees in the nursery usually open and unfold their terminal buds so rapidly that the larvae apparently do not have sufficient time to inflict serious damage. It has been noticed, further, that the larvae feed on the foliage (fig. 39) if compelled to do so by the rapid growth of the tree, and under these conditions they will eat the outer parts of the leaves. During dry seasons, especially in the spring of the year, pecan nursery stock grows very slowly and is seriously injured by larvae of the bud moth. As a nursery practice it is strongly recommended that the trees be kept in a vigorous growing condition by thorough cultivation and fertilization.

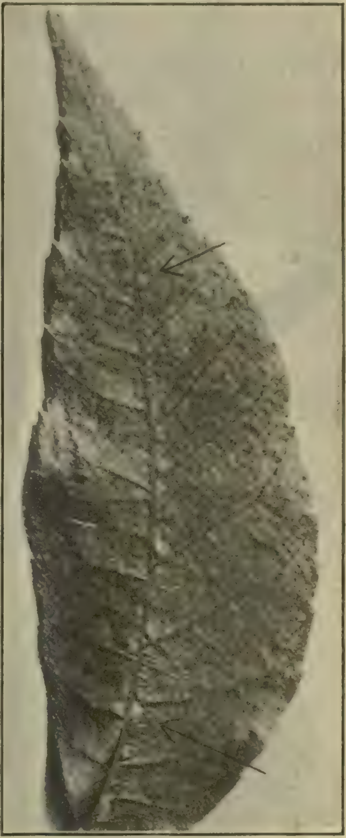

FIGURE 37.—Eggs of the pecan bud moth on pecan leaflet

Spraying with calcium arsenate during the spring and summer will help materially in holding this pest in check. When this insect is to be controlled the calcium arsenate should be used at the rate of 1 pound to each 50 gallons of 3–4–50 Bordeaux mixture. Calcium arsenate should never be used unless combined with Bordeaux mixture, as foliage injury might result when this insecticide is used alone or with hydrated lime. As there are several generations of this insect, and as the trees are growing continually during the spring and summer months, four or five applications should be made, timing the applications about three or four weeks apart. Nurserymen sometimes spray for the control of nursery blight, making four or five applications of Bordeaux mixture, and where the bud moth becomes serious in nurseries where control measures are used against this

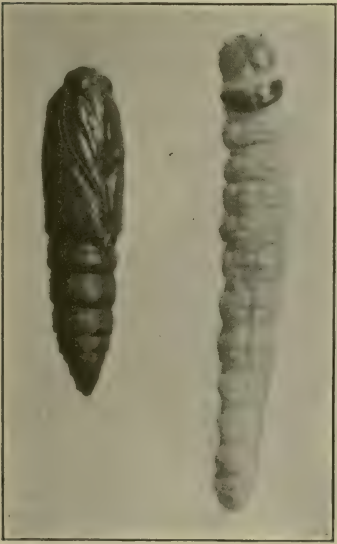

FIGURE 38.—Pupa and larva of the pecan bud moth: Pupa at left, larva at right. Enlarged 4 diameters

disease, calcium arsenate may be incorporated in the Bordeaux mixture as directed above. Observations indicate that the pecan bud moth never does sufficient damage in bearing orchards to warrant special spray applications.

MAY BEETLES

May beetles or June bugs (*Phyllophaga* sp.) are often reported as seriously defoliating pecan trees in the spring while the leaves and shoots are growing vigorously. Small trees receive the worst injury. The beetles feed at night, while in the daytime they lie hidden just beneath the surface of the ground. These insects are well known from their habit of flying to lights.

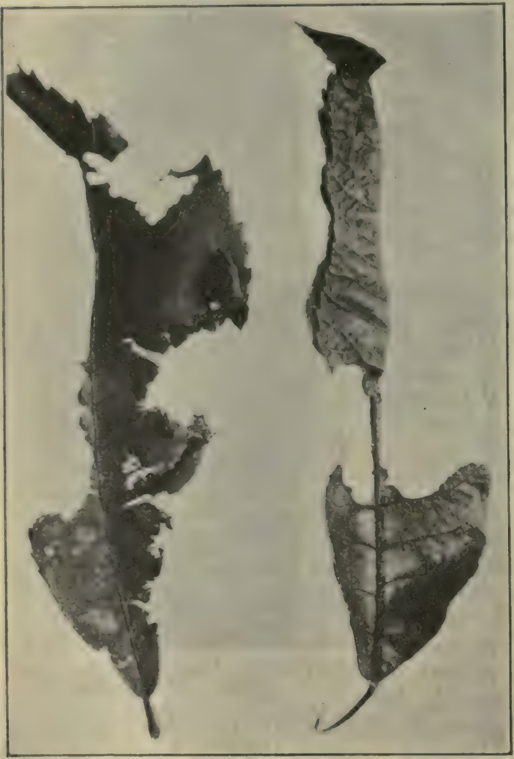
FIGURE 39.—Injury to pecan foliage by larvae of the pecan bud moth

The beetles or adults (fig. 40) are from one-half to three-fourths of an inch long, robust, and usually rich brown in color. They lay their eggs upon the soil, and the larvae, which are the notorious white grubs, burrow into the ground and spend their existence feeding upon the roots of plants, particularly grasses. Usually two years are required for development, and pupation takes place in the larval tunnel. (Fig. 41.) The adults work their way up through the soil and fly to the trees.

CONTROL

Since the young of May beetles are primarily grass feeders, they will seldom be injurious in well-cultivated orchards. Fields in the vicinity of orchards are a source of infestation, but if the soil is plowed as often as once a year the May beetles never become very numerous.

In the case of young trees, beetles may be hand picked or shaken onto sheets on the ground at night, and destroyed. They may also be caught in trap lanterns.

THE FALL WEBWORM

Perhaps the commonest insect under the observation of pecan growers is the so-called fall webworm (*Hyphantria cunea* Drury), which constructs unsightly nests or webs over the twigs and foliage. These webs are more abundant during the late summer and fall, but since this insect has two generations in the South, the webs are to be found on pecan trees as early as May. Trees defoliated in late summer frequently develop new leaves and flowers to the detriment of the crop the following year.

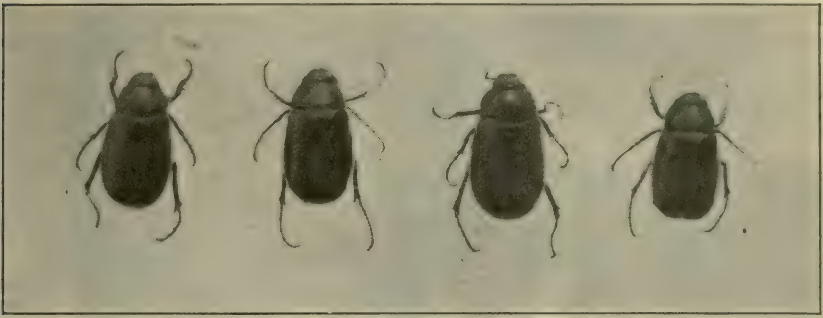

FIGURE 40.—Adult May beetles. Natural size

The moths (fig. 42), which usually are pure white but sometimes have black or brown spots on the forewings, emerge in the spring, in April and May. The eggs are deposited in masses on the leaves, are greenish-white in color, and hatch in about a week. The larvae are gregarious, each colony forming a web in which all the caterpillars feed, eating the upper and lower surfaces of the leaves.

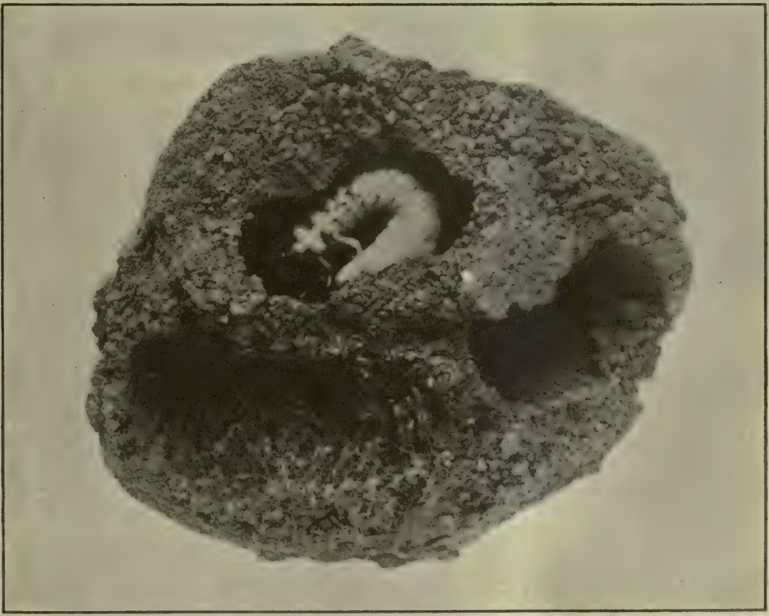

FIGURE 41.—Larva of May beetle in its cell in the ground

When they need additional leaves for food they enlarge the web (fig. 43), which may become very large and conspicuous.

The full-grown larvae (fig. 44) usually measure an inch in length, and are covered with long white and black hairs arising from numerous black tubercles. On reaching maturity they leave their webs and transform to brown pupae in flimsy, hairy cocoons beneath rubbish on the ground, under the scales of bark, or just under the surface of loose soil. The earliest date for the emergence of moths of the first generation is June 26, but most of the moths of this generation do not appear until later. The second-generation larvae have been found deserting their webs during the latter part of September, all through October, and occasionally as late as the first week in November, for the purpose of pupation. This insect passes the winter in the pupal stage, the moths appearing the following year, during April and May.

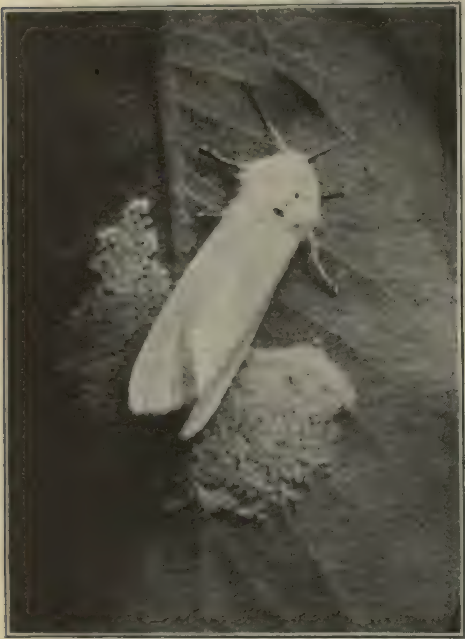

FIGURE 42.—Moth and egg mass of the fall webworm. Enlarged 2 diameters

CONTROL

When this insect is not abundant it is more practical to remove the webs from the trees by means of a long-handled tree pruner or by using a long bamboo pole. Sometimes burning the webs on the trees will be found practicable, but it should be done carefully, so that not much of the foliage will be scorched. When this insect becomes abundant, as is the case in some years, spraying with calcium arsenate at the rate of 1 pound to each 50 gallons of 3-4-50 Bordeaux mixture may be used effectively. Calcium arsenate may be incorporated in any one of the Bordeaux mixture applications as used for pecan scab during the spring or summer, depending on the severity of the attack by this insect.

THE WALNUT CATERPILLAR

In the South, branches of large pecan trees are often defoliated by colonies of a caterpillar which when full grown is black, with long whitish hairs, and nearly 2 inches in length. This is the so-called walnut caterpillar (*Datana integerrima* G. and R.). When young it is brownish, with white stripes and somewhat more hairy than the matured larva. Upon hatching from eggs, which are deposited in masses (fig. 45) on the underside of the leaves, the larvae feed at first only on the underside of the leaflets, but later they devour the

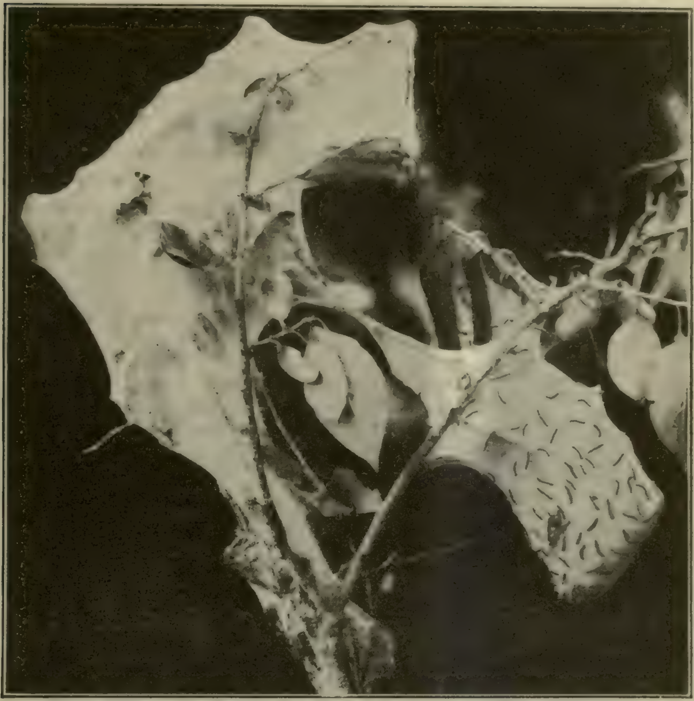

FIGURE 43.—Web and caterpillars of the fall webworm

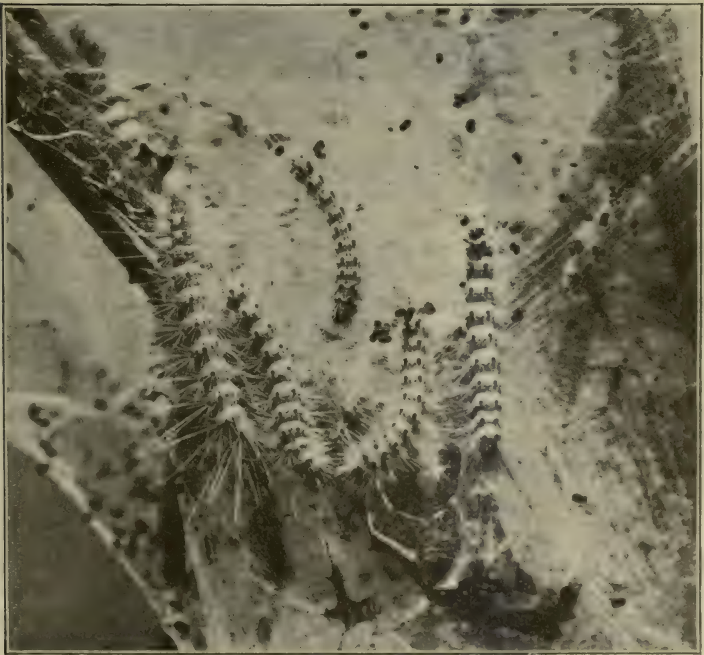

FIGURE 44.—Portion of a web of the fall webworm showing caterpillars. Enlarged 1½ diameters

entire leaf except the midribs and petioles. Small pecan trees, especially nursery stock, are sometimes completely defoliated, and it is not uncommon to see large branches on bearing trees stripped of their foliage. The larvae feed in colonies (fig. 46), and when molting the larger caterpillars invariably leave their feeding place and crawl to the trunk or larger limbs, where in a mass they shed their skins, which may adhere to the bark for several weeks or longer. After molting they ascend the tree to continue their feeding depredations, and when full grown crawl down the trunk and immediately enter the soil to a depth of a few inches. Here, in a day or two, pupation takes place.

In the North this insect has only one generation yearly, but evidently at least two generations occur in the South.

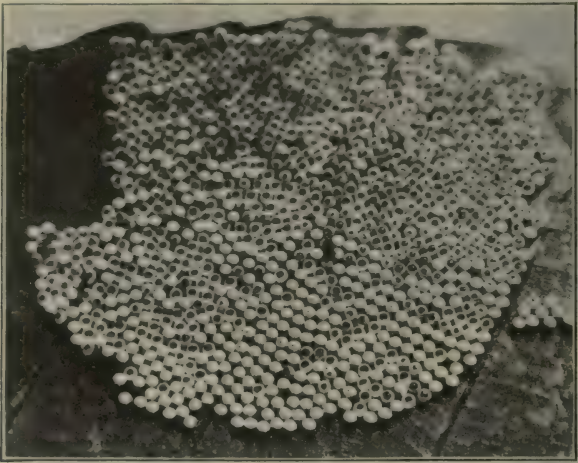

FIGURE 45.—Egg mass of the walnut caterpillar. Enlarged 2½ diameters

According to Bureau of Entomology records the moths (fig. 47) developing from overwintering pupae emerge from April 15 to July 15. Shortly after emergence egg laying takes place. The eggs, which are laid in masses of from 100 to several hundred on the underside of the leaflets, hatch in a little less than a week, and the larvae feed for 25 days or longer before completing their growth. The caterpillars enter the soil to transform to brown pupae. (Fig. 48.) Those of the first generation remain in the pupal stage about 18 days. The second-generation larvae enter the soil from the middle of September until the last week in October. They pass the winter as pupae in the ground, and the moths do not emerge until the following spring or early summer.

CONTROL

Whenever the egg masses or colonies of the caterpillars are discovered they should be promptly destroyed. In some seasons the egg masses of this species are highly parasitized, and the parasites aid materially in keeping the pest in check. The larger larvae may often be found massed on the tree trunks in the act of molting, and these should be destroyed by crushing or by some other suitable means. Pecan orchards sprayed with such arsenicals as are used against the pecan leaf casebearer and similar insects will rarely suffer serious damage from the walnut caterpillar.

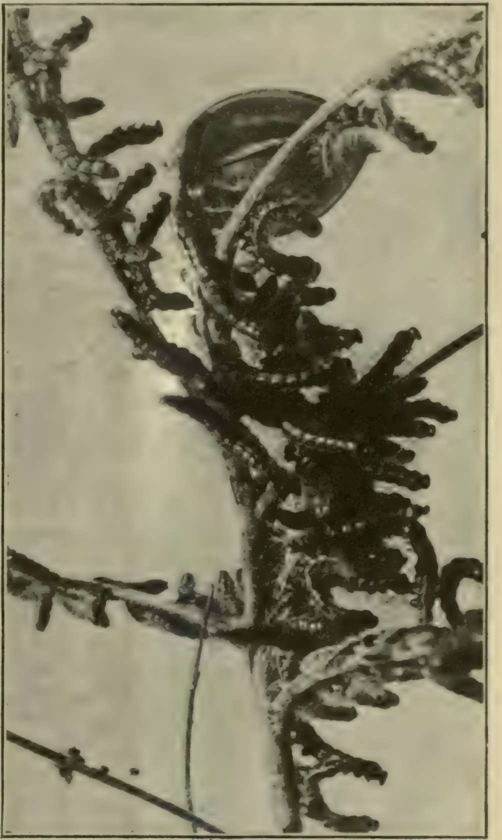

FIGURE 46.—Colony of walnut caterpillars on pecan twig

PECAN APHIDS

In midsummer the leaves of pecan trees are often found coated or spotted with a sticky glistening liquid commonly called honeydew. This substance is produced by aphids, or plant lice, which are small sucking insects. As they feed for the most part on the underside of the leaves this liquid drops to the tops of the leaves below. Later a fungus growth develops in this honeydew, causing the foliage to appear black and sooty.

There are four kinds of aphids commonly occurring on pecan and they can readily be distinguished. Only one of these, the black pecan aphid, seems to be harmful. They feed on various species of hickory, besides pecan, and are found generally distributed over the eastern half of the United States.

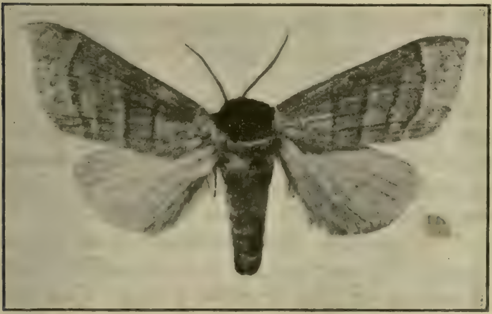

FIGURE 47.—Adult, or moth, of the walnut caterpillar. Enlarged 2 diameters

THE BLACK PECAN APHID

The black pecan aphid (*Myzocallis fumipennellus* Fitch) has attracted attention as a pecan pest only in recent years, though it has long been known to occur on hickory. It was originally reported on pecan from western Texas and now occurs through the Gulf States and North Carolina. It causes a conspicuous discoloration of the leaves and may cause defoliation.

The black pecan aphid will be recognized in all stages by its dark body. It is one-sixteenth of an inch long and rather robust. Its back bears a number of tubercles and is decorated with white dots of wax. The adult summer female has two pairs of wings. Its young are wingless.

In the spring young aphids hatch from overwintering eggs and move to the newly opened leaves. Here they feed and become adult aphids, all of which are females capable of producing live young without the intervention of males. At least 20 consecutive generations of these females may be produced during the summer in southern Georgia. About the middle or last of October, when the leaves begin to fall, sex forms appear, winged males and wingless females, which mate on the leaves. After fertilization the females travel downward on the trunks and deposit from 15 to 20 eggs in small crevices in the bark.

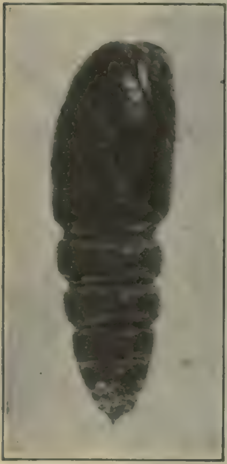
FIGURE 48.—Pupa of the walnut caterpillar. Enlarged 3 diameters

The adults are quite active and readily jump when disturbed. The young may wander some distance from their place of birth before settling down to feed; as a result they are not found in crowded colonies. Adults and young live on the under surfaces of the leaves, though occasionally they feed on the upper surface.

The black pecan aphid is notable for the marked effect of its feeding on the foliage. Soon after the young or nymphs start sucking juice, bright yellow blotches develop around the punctures and grow till about one-fourth of an inch across. (Fig. 49.) Often these blotches merge to form larger areas. The feeding of many aphids blotches the leaves so as to make them quite conspicuous in an orchard. In a short time the yellow areas turn brown and if numerous enough cause the leaflet to wither and drop. Thus a heavy infestation of the black pecan aphid may cause defoliation in the late summer.

CONTROL OF THE BLACK PECAN APHID

Applications of nicotine sulphate made in the spring after the foliage is well out and again in the late summer have given the best results. In pecan groves where the black pecan aphid continues to be instrumental in causing considerable defoliation, two applications will generally be necessary. Usually four applications of Bordeaux mixture are applied to pecans for the control of pecan scab, and since nicotine sulphate (40 per cent) is compatible with Bordeaux mixture, it may be added at the desired time. The first application for pecan scab usually is made about the middle of May. The nicotine sulphate, 40 per cent, should be incorporated in this application at the rate of 1 to 1,000 or three-fourths of a pint to each 100 gallons of the Bordeaux mixture. This early application will serve to check the insect until such time as it may be necessary to make the second application of the nicotine sulphate. As this aphid spends its entire life on the pecan throughout the year, the suppression of the insect by one application of nicotine sulphate in the spring will not guarantee freedom from it during midsummer or late summer, and an additional application will be necessary. The second application of nicotine sulphate should generally be made with the fourth application of Bordeaux mixture as applied for pecan scab. It will largely be a question for the individual grower to decide whether under his conditions the degree of infestation is such that the nicotine sulphate should be incorporated in the third or in the fourth application of Bordeaux mixture as applied for pecan scab.

That aphids are not readily killed by a spray that does not wet them is well known. Nicotine sulphate should never be used without the addition of some ingredient which will spread it, as the effectiveness of a spray against aphids is largely dependent on its wetting capacity. Bordeaux mixture, being colloidal in nature, makes a fairly good spreader for nicotine sulphate. Whenever a pecan grower desires to control the black pecan aphid, where Bordeaux mixture is not used, nicotine sulphate should always be combined with soap at the rate of 4 pounds to each 100 gallons of the spray, to insure its spreading.

When spraying against this insect, the pecan grower should endeavor to apply the spray thoroughly to all parts of the tree and not overlook the centers. As this insect has many generations during the year, it can readily be seen that if the centers of the trees are neglected reinfestation can very easily result.

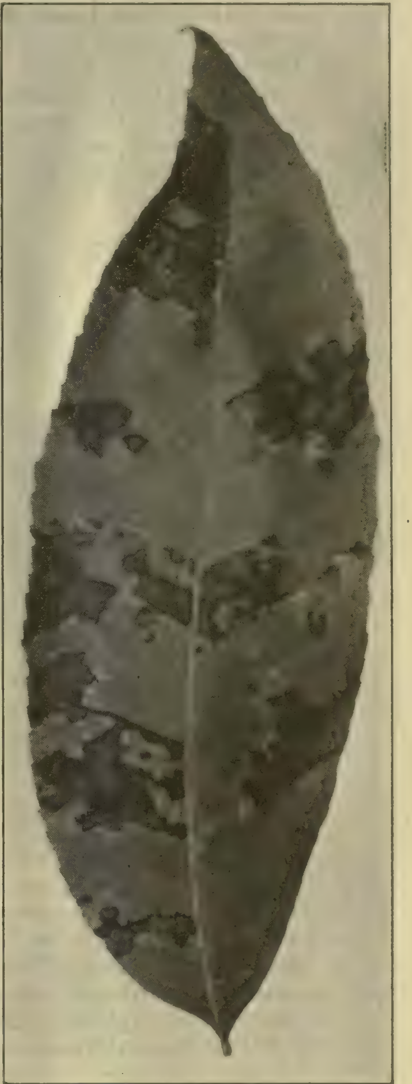

FIGURE 49.—Pecan leaflet injured by the black pecan aphid

OTHER APHIDS ON PECAN

Two yellow species, a yellow hickory aphid (*Monellia* sp., as yet undescribed, formerly erroneously called *M. caryella* Fitch), and the black-margined aphid (*M. costalis* Fitch), are often found in abundance attacking the undersides of the leaves. Though exceedingly plentiful during the growing season, these species have never been observed to cause injury to the pecan. It may be, however, that the great quantity of honeydew, which they excrete on the leaves, interferes to some extent with the proper respiratory action of the plant.

The yellow hickory aphid is the smallest of those living on pecan. It is pale yellow with black rings upon the antennae. The young have six rows of spines down the back.

The black-margined aphid is somewhat larger than the yellow hickory aphid, flatter, and also brighter yellow in color. Its antennae are ringed in the same way. On the front and sides of the head, sides of the thorax, and front edges of the forewings is a conspicuous black line. This species is unlike any other aphid on pecan in that when resting it holds its wings flat on the back. The others hold their wings upright or rooflike. The young of the black-margined aphid have four rows of spines on the back.

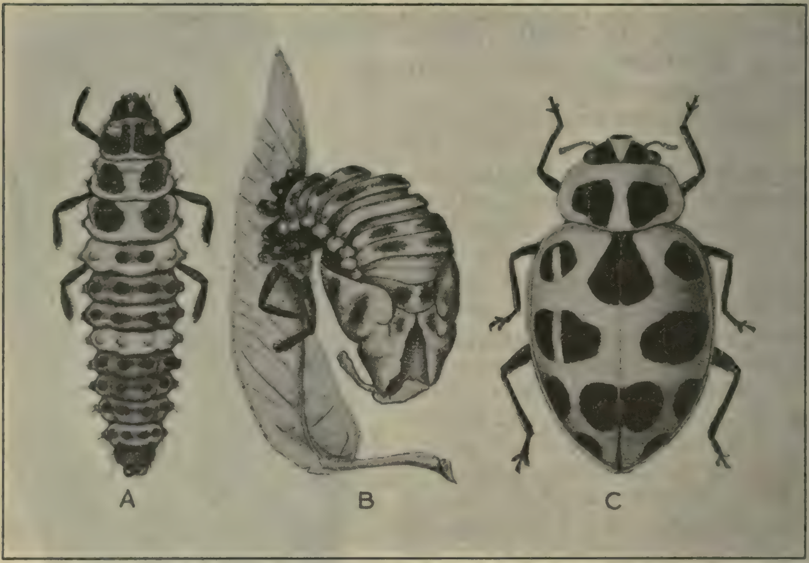

FIGURE 50.—Spotted ladybird beetle: A. Larva; B, empty pupal skin; C, adult. Enlarged 8 diameters

Both of the yellow aphids have practically the same life history as the black pecan aphid. The three species have the same number of forms and live through summer and winter in the same manner. The yellow hickory aphid is the most abundant in the spring.

The fourth species of aphid on pecan is commonly called the giant hickory aphid (*Longistigma caryae* Harris). It is found on the branches of several kinds of trees, especially on oak and sycamore and less frequently on pecan and hickory. It does not attack the foliage but obtains its food from the twigs and branches. It is one-fourth of an inch long, one of the largest aphids known. The body is gray with numerous black spots.

The life history of this large species in the South has not been fully ascertained, but it is known to feed throughout the year. On pecan it is more apparent during the cold months on the bare branches than in the growing season. This aphid is found in crowded colonies so thick on branches that they resemble small swarms of bees.

As stated before, only the black pecan aphid has proved injurious. If the other aphids become abundant the same measures as suggested for the black pecan aphid might be tried. A heavy infestation of aphids is likely to follow the application of spray or dust for the control of other insects.

NATURAL CONTROL OF THE APHIDS

A number of predacious insects, including ladybird beetles, the larvae of lacewing flies, and one internal parasite (*Aphelinus perpallidus* Gahan), are known to attack the three smaller aphids. These cut down the numbers of aphids enormously.

The ladybird beetles are almost hemispherical in shape, one-fourth of an inch or less in length, and usually bright colored. The spotted ladybird beetle (*Ceratomegilla fuscilabris* Muls.), which has been observed eating pecan aphids, is red with black spots. (Fig. 50.) Another common one (*Chilocorus bivulnerus* Muls.) is shining black with red spots. The young of these insects are elongate and soft bodied, with long legs. (Fig. 50, A.) During the winter the adult ladybird beetles hide beneath the loose bark of trees and in piles of débris on the ground. Growers should learn to recognize these predacious insects and not destroy them, as they are beneficial.

The lacewing-fly larvae are similar to the ladybird beetle larvae with the addition of long pincherlike jaws with which to catch their prey.

Weather conditions also influence the abundance of aphids; a hot dry spell tends to increase their numbers, and cold wet weather has the opposite effect. Entomogenous fungi also play a part in the reduction of aphids. A fungus often found on the black pecan aphid is a species of Cladosporium. Aphids will be found in greater numbers on pecan trees adjacent to buildings where they are somewhat protected from wind and rain.

THE PHYLLOXERA

Pecan growers are ocasionally alarmed by the presence of tumorlike swellings or galls (fig. 51) which come on the leaves, leaf stalks and succulent shoots. These galls are caused by the attacks of a class of insects known as phylloxera (*Phylloxera caryaecaulis* Fitch, and other species), closely related to the aphids, and are in no way to be associated with a disease organism, as seems to be a more or less prevalent notion among pecan growers. An examination of the interior of a newly matured gall will reveal the true culprit in both winged and wingless or immature forms. Some species of phylloxera attack certain kinds of hickory as well as the pecan. The phylloxera is able to produce galls only on growing tissue, and hence the formation of galls is more pronounced during the early spring, although galls are found on the trees throughout the year. The young phylloxera chooses a place and commences to feed by sucking the sap from an opening leaf or fast-growing shoot. This action stimulates an abnormal plant growth which finally forms a gall and incloses the insect. Secondary growth of foliage induced by defoliation by caterpillars is likely to be atacked by phylloxera, as well as the spring growth. Both the seedling and improved varieties of pecan are subject to attacks of these insects, but it appears that injury is much more prevalent on the seedlings. In the nursery it is not uncommon to find seedling stock covered with galls while some budded or grafted varieties growing adjacent escape injury.

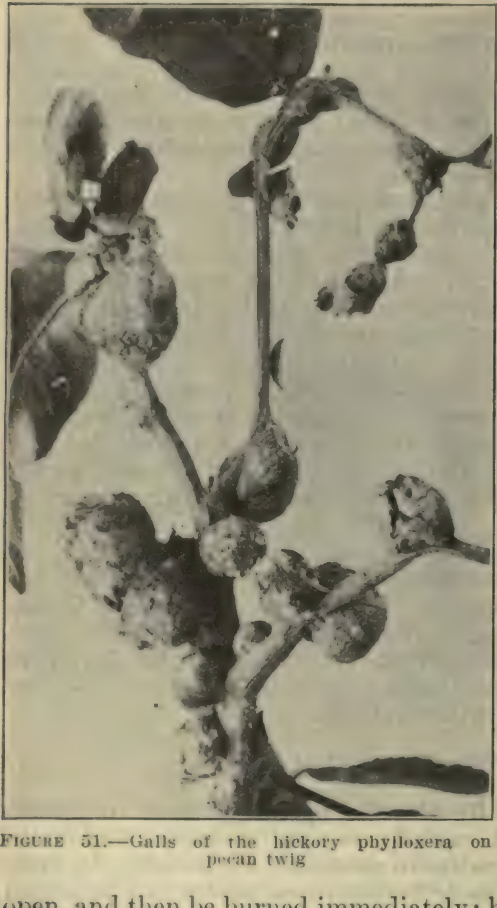

FIGURE 51.—Galls of the hickory phylloxera on pecan twig

CONTROL

Under ordinary circumstances pecan trees slightly infested by this insect will hardly demand special remedial measures. Like many other insects, this species is subject to great fluctuation in numbers, and the amount of damage therefore will vary considerably from year to year. This variation in abundance is due to the fact that the insect is held more or less completely in check by natural enemies.

So far as present knowledge of this insect goes, no very satisfactory method of control can be employed during the growing season on trees that are badly affected. It has been recommended that as many as possible of the affected leaves and shoots be clipped off by means of a long pruner before the galls open, and then be burned immediately; but this treatment will hardly prove feasible for large trees. If certain varieties of pecans show an exceptional susceptibility to infestation year after year, top-working such trees with resistant sorts doubtless would prove a practicable means of avoiding serious damage by this pest.

INSECTS INJURING THE TRUNK AND BRANCHES

THE FLAT-HEADED APPLE-TREE BORER

The flat-headed apple-tree borer (*Chrysobothris femorata* Fab.) has long been known as a more or less serious pest of certain fruit trees, such as apple, quince, pear, peach, and apricot, and among its food plants are included several shade and forest trees. This insect is recognized in many sections of the pecan-growing belt as a serious pest of pecan trees grown under orchard conditions, and in innumerable cases its larvae have girdled and killed young trees. Its injuries are for the most part restricted to newly transplanted nursery trees and to trees devitalized by poor cultural methods or unfavorable weather conditions. Pecan trees that have been affected by winter injury or sun scald are very susceptible to the attacks of this borer. It is well known that pecan nursery stock does not stand transplanting so well as do many orchard fruit trees, as, for instance, the apple or peach, possibly because so much of the taproot is cut off in removing the trees from the nursery row. For the first year or two after being set out nursery trees make slow growth and do little more than establish themselves, even when the planting is done at what is considered the best time and with utmost care. If the spring and summer following the setting out of the young trees are deficient in rainfall, the trees may be more or less seriously attacked by flat-headed borers, as the beetles seem to prefer to lay their eggs upon weakened trees.

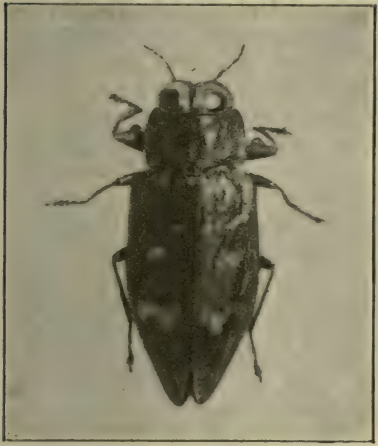

FIGURE 52.—Adult beetle of the flat-headed apple-tree borer. Enlarged 3½ diameters

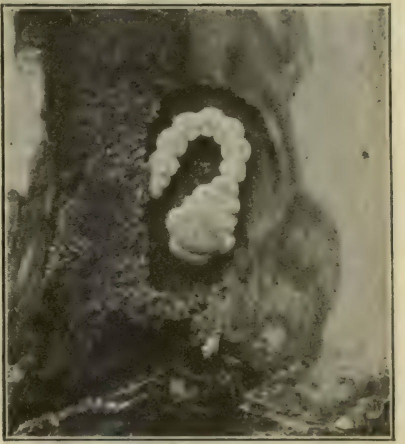

FIGURE 53.—A flat-headed apple-tree borer in its tunnel. Enlarged 2 diameters

DESCRIPTION

The beetle, as represented in Figure 52, is oval and flattened and about one-half inch in length, but the size is somewhat variable. The upper surface has a brownish metallic luster, the color of the underside is coppery bronze, and the part of the body underneath the wing covers is bright metallic greenish blue. The markings on the back, or wing covers, are shown in the illustration.

The larva (fig. 53) when full grown is about an inch long, without legs, and yellowish white. The second segment is much broadened and compressed, giving the larva the appearance of having a large flattened head. The larvae within their galleries always assume a curved position, somewhat as is shown in the figure.

The pupa (fig. 54) is also yellowish white, somewhat more yellow than the larva, and shows the undeveloped appendages and structures of the adult beetle.

SEASONAL HISTORY AND HABITS

The beetles are to be found from March to November in pecan orchards, but they are especially abundant at two periods, namely, during May and from the middle of August until mid September. They deposit their eggs in cracks or under bark scales upon the trunk or larger limbs. The young larva gnaws through the bark and begins to feed upon the sapwood immediately beneath, making a more or less irregular gallery packed with sawdust castings. Some galleries have a tortuous or spiral course (fig. 55), and because of this, young trees are often girdled. If the trees are able to maintain considerable vitality in spite of the attacks, the larvae do not enter the sapwood to transform to pupae, as they do in dead and dying trees, but transformation takes place immediately under the bark, a slight excavation being made in the sapwood. One year is required for the complete development from egg to adult. Because of the different sizes of larvae that may be found in trees at almost any season of the year, many growers believe that the insect has more than one generation. This, however, is to be explained by the great variation in rate of growth of the larvae and the consequent variation in time of emergence of the beetles, which takes place any time from March until early autumn.

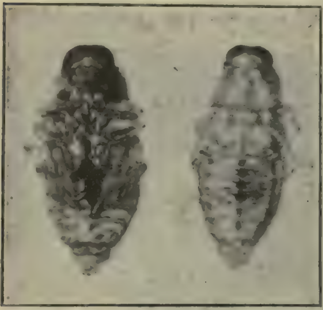

FIGURE 54.—Pupa of the flat-headed apple-tree borer viewed from above (at right) and from below (left). Enlarged 2½ diameters

CONTROL

After borers have gained entrance to the trees, nothing better can be done than to examine the trees carefully and remove the larvae with a knife. The point of infestation on the trunk or limb can usually be detected by the discoloration and depression of the bark, which sometimes cracks open. In badly infested orchards the trees should be examined at least twice a year, and perhaps a third time would be worth while. In cutting out worms great care should be taken not to cause any unnecessary injury to the trees, and the places from which the borers have been removed should be treated with a good tree paint.

Much better than "worming" trees is to prevent infestation. Trees can be protected from egg laying by wrapping the trunks with heavy paper or burlap, which should extend from the ground to the branches and should be tied at the top and mounded with earth at the bottom. Apply the wrappers in March and remove them in November, as egg laying occurs at any time throughout this period.

In pecan orchards the use of trap logs made from newly cut branches of any favorite host plant, to attract the adult beetles for egg laying, may be found practicable, for it is well known that this insect prefers dead or dying wood to living trees. Perhaps oak would be the best and most available wood, but hickory or pecan would serve the same purpose, as the borer breeds readily in all of them. These trap logs, from 4 to 6 feet in length and from 3 to 4 inches in diameter, should be placed at intervals of 100 feet or less during the late winter or very early spring. By smearing the logs with some lasting sticky material a good many beetles may be caught and killed. After these logs have been left in the orchard for one season they should be burned.

Careful cultural methods are strongly urged as a measure of protection. Trees should not be injured by cultivating implements, as wounds so made offer attractive places for egg laying. All dead and dying trees and all pruned limbs or branches should be removed promptly and burned, for such wood affords an ideal breeding place for the borer and is therefore a menace to the orchard. The keeping of pecan wood about the orchard for future use as fuel or for other purposes is bad orchard practice and can not be condemned too strongly.

It is recommended that 1-year-old trees be planted, as such trees recover from the shock much more readily than trees which are allowed to grow in the nursery too long. In the transplanting of nursery stock to the orchard, every care should be taken to have the trees set out under the best conditions; and, judging from observations, early planting, say in December and January, and not later than February, is to be recommended, so that the trees will get the benefit of the winter rains. It is also essential that young trees be kept in a vigorous growing condition by frequent cultivation and the planting of tree rows to some suitable leguminous crop. The proper use of fertilizers also will help the trees to withstand attack of this as well as of other wood-boring insects. It is

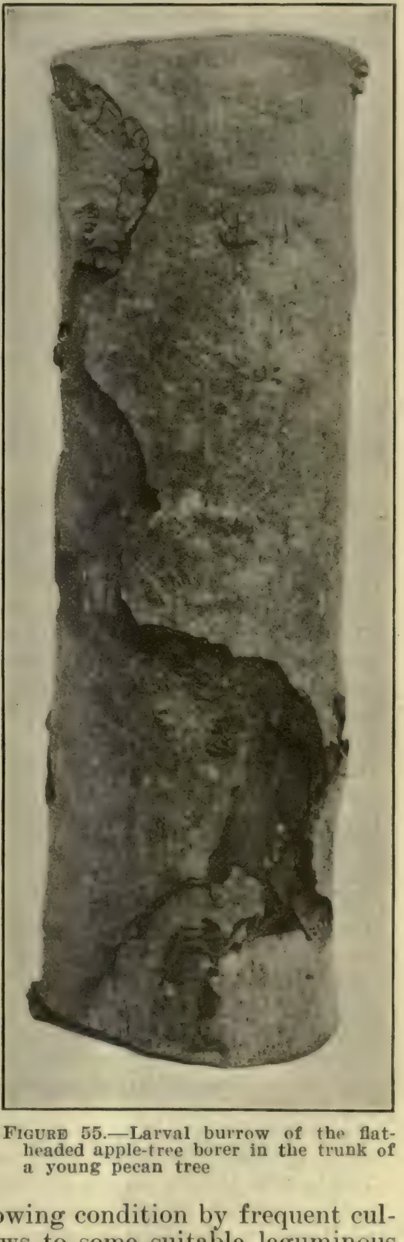
FIGURE 55.—Larval burrow of the flat-headed apple-tree borer in the trunk of a young pecan tree

important to remember that thrifty trees are less liable to attack than sickly or stunted ones, and injury is best avoided by the maintenance of trees in a vigorous condition of growth.

THE OAK OR HICKORY COSSID

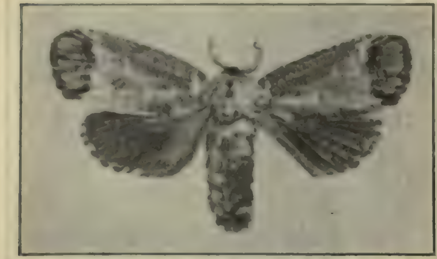

FIGURE 56.—Adult of the oak or hickory cossid. Slightly enlarged

The oak or hickory cossid (*Cossula magnifica* Strecker) in its larval state inhabits the trunk or larger branches of pecan, hickory, and oak, in which it bores or tunnels in the hard wood, making galleries several inches in length. The work of the larvae is detected rather readily by the heaps of reddish pellets of wood that collect at the base of the tree trunks. A careful examination of the affected trees will reveal the hole from which these castings are pushed out by the larvae in order that their galleries may be kept clear. The hole is about the size of a lead pencil and is closed by four flaps composed of silk and bits of chewed wood.

DESCRIPTION

The moth (fig. 56) generally is gray, mottled with brown and black blotches, and has a wing expanse of about 1¾ inches. Each forewing has a large, light-brown patch, sprinkled at the end with dark-brown streaks. The hind wings are darker gray than the forewings and are without markings. The head is brown, the thorax light gray, peppered with faint dark spots, and the abdomen brownish gray.

The full-grown larva (fig. 57) is about 1½ inches in length. The body is pinkish in general color and covered sparsely with short fine hairs which arise from the numerous tubercles. The head, cervical shield, or neck, and plates on the hind end of the body are shiny dark brown.

The pupa, to which the larva transforms upon attaining full growth, is generally brown, except the forward part, which is blackish. On its head is a sharp projection which is of assistance to the pupa in pushing its way out of the larval burrow preparatory to the emergence of the adult moth.

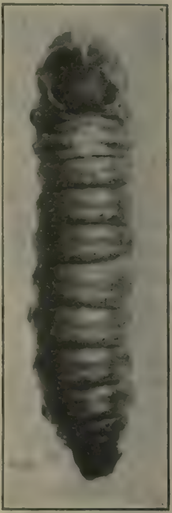

FIGURE 57.—Larva of the oak or hickory cossid. Enlarged 1½ diameters

SEASONAL HISTORY AND HABITS

The complete life cycle of this insect is not known, but it probably occupies only one year in the extreme South, and longer in its northern distribution. The moths emerge usually during May and June, and lay their eggs shortly after their appearance. The larvae upon hatching first attack small twigs, in which they tunnel out the center or pithy wood. (Fig. 58.) When the larva has grown too large for the small twig in which it has been feeding, it crawls out and enters a larger one. By early fall the larvae will be found attacking the tree trunks or large lower branches, in which they bore into the hard wood and make their galleries parallel with the grain. At this time and during the spring months the grower can detect the castings at the base of the trees which identify the work of this insect. The transformation to pupa takes place within the larval gallery during April or May. In about one month the pupa wriggles along the tunnel to the exit hole, the moth emerges, and the split pupal case is left protruding a little from the opening.

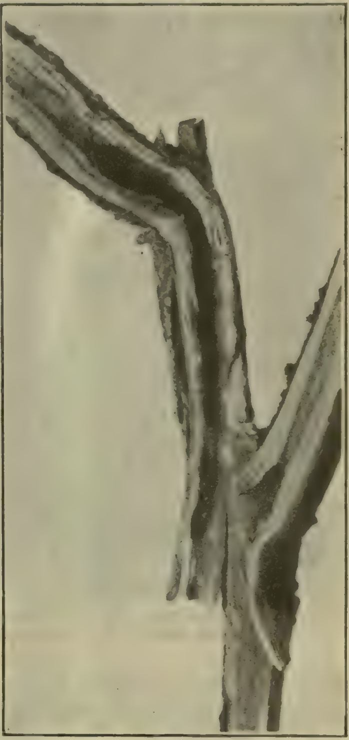

Figure 58.—Larval burrow of the oak or hickory cossid in pecan twig

CONTROL

All that can be done to control this insect in pecan orchards is to locate the larger limbs and tree trunks attacked, and destroy the larvae by injecting small quantities of carbon disulphide into the holes by means of a medicine dropper or oil can. The holes should then be closed immediately after treatment by means of putty, grafting wax, wooden pegs, or moist clay.

SHOT-HOLE BORERS

Small beetles called shot-hole borers (*Xylobiops basilare* Say; also species of Xyleborus) may frequently be found infesting the trunk and branches of dead or dying pecan trees. It has been observed by some that not infrequently the borers are charged with being responsible for the unhealthy and apparently diseased condition of the tree, whereas actually the diseased condition of the trunks is responsible for the presence of the insects.

The larvae bore to a considerable depth. The borings or frass of the larvae are very fine and sawdustlike in appearance, and are firmly packed or compressed within the galleries, which run with the grain of the wood. Upon attaining full growth the larvae pupate some time during the fall or spring, and the beetles emerge during the spring months. Beetles are sometimes found during the early winter in the larval galleries, in which they remain until warm weather begins. The beetles invariably make their way out at right angles to the larval galleries, and emerge through circular holes in the bark, as is shown in Figure 59.

The adult of one of the more common species is black and has small punctures over the greater part of its body. The wing covers are reddish at the base or shoulder, and at the tip or posterior end they are obliquely cut off, the edge of the cut being armed with three conspicuous teeth. This beetle is one-fourth of an inch long. Other shot-hole borers are much smaller.

CONTROL MEASURES

Since these insects attack, as a rule, only dead or dying pecan wood, they are not to be considered a serious pest. Moreover, since they attack trees in an unhealthy condition, the trees should be kept vigorously growing by practicing good orchard management. Where trees are beyond rejuvenation and the borers have become numerous, such trees or portions of trees should be removed. As a protection against shot-hole borers, as well as against the more injurious wood-boring species, all dead trees and prunings should be promptly removed from the orchard and burned.

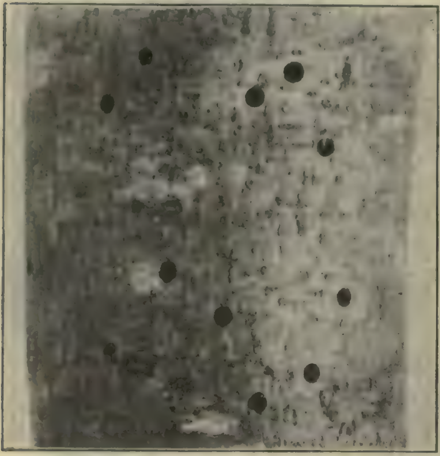

FIGURE 59.—Exit holes of adult beetles of the red-shouldered shot-hole borer

THE PECAN BORER

An insect which has been reported as attacking the pecan in North Carolina, Florida, Georgia, and Mississippi is the pecan borer (*Aegeria scitula* Harris). The work of the larvae is confined to the inner bark and sapwood, where they make winding tunnels which usually run up the trunk. This species differs from the peach borer, a closely related insect, in that it works in the trunk and branches above ground.

The feeding of a larva in the trunk of the tree is never serious, and seldom is it destructive except in young trees. In tunneling about a growing patch bud, however, the injury often becomes so extensive that the bud is girdled (fig. 60), and in other instances the buds are checked in their growth. Where large pecan trees are top worked, the buds are often seriously injured by this insect. The larvae feed underneath the bark throughout the winter.

The full-grown larva is creamy white with a reddish head and is one-half of an inch in length. The overwintering larva on reaching maturity in the spring pushes some of the frass from the tunnel through a hole in the bark and transforms to a pupa in a silken cocoon spun in a cleaned-out portion of the tunnel. On emerging the moth leaves its empty pupal case partly protruding from the tunnel (fig. 60), usually from beneath a scale of the bark. The adult (fig. 61) is one of the clear-winged moths, blue black with yellow markings. The wings of both male and female are devoid of scales and expand about four-fifths of an inch. The moths emerge from March to the last of May and lay their eggs on the bark of the trees. The winter is passed by the larva feeding underneath the bark.

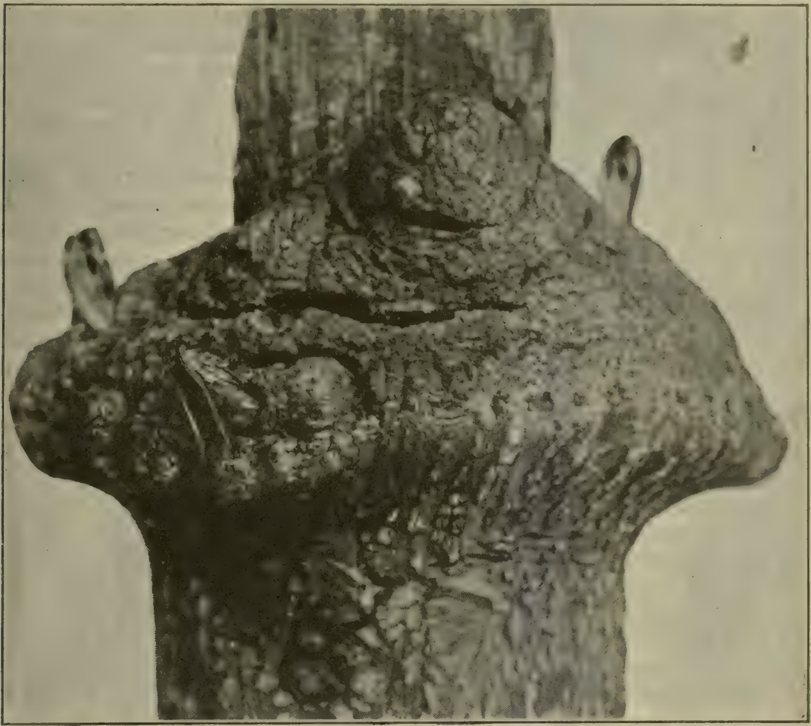

FIGURE 60.—Injury to a patch bud caused by larvae of the pecan borer. Pupal skins are seen protruding from the burrows

CONTROL MEASURES

The presence of the larvae can be detected by the reddish excrement particles protruding in small heaps from the tunnels, and the insect may be easily removed with a knife. When seedling stock is patch budded or where trees are cut back and then budded or grafted, it is advisable to examine the inserted buds in early fall for signs of this larva. It has been found that buds which are carefully wrapped with waxed tape are seldom injured.

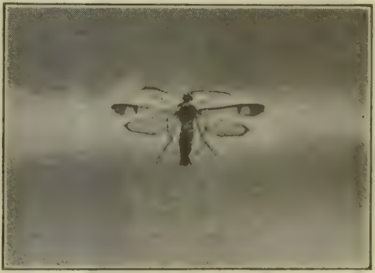

FIGURE 61.—Adult of the pecan borer

THE TWIG GIRDLER

Most pecan growers are familiar with the twig girdler (*Oncideres cingulatus* Say) which is responsible for the cutting off or pruning of pecan twigs during the late summer and early fall.

This beetle inhabits a wide range of territory, being found in most of the Eastern, Central, and Southern States, but in its more northern

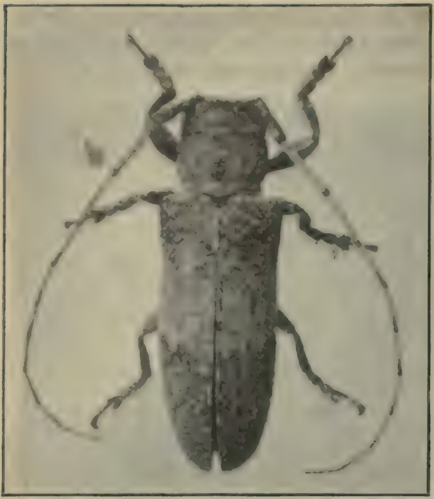

FIGURE 62.—Adult or beetle of the twig girdler. Enlarged 3 diameters

distribution it does not do much injury. In the pecan-growing sections of the South it ranks as an important pest because of the excessive cutting of branches from pecan trees in orchard and nursery by the adult beetles. Besides the pecan, it has been reported as damaging the hickory, persimmon, oak, walnut, elm, maple, locust, linden, and various pome and stone fruits, including apple, pear, quince, cherry, peach, and plum, as well as orange trees and rose bushes. In the South, however, it seems to confine its attacks, for the most part, to the pecan, hickory, and persimmon.

When the beetles occur in abundance they may do much damage by severing branches for the purpose of egg laying. It is not uncommon to see the ground under pecan or hickory trees literally covered with twigs, many bearing clusters of maturing nuts, that have been cut off by the beetles, and twigs often accumulate in the tree tops in conspicuous bunches. By this cutting off of the tips of the branches the fruiting area of the tree for the following year is greatly reduced and the nut crop indirectly affected. This type of injury, besides affecting the nut production, causes the development of many offshoots, which destroys to some extent the symmetry of the tree. Pecan nurseries adjacent to a badly infested territory often suffer great loss from the girdling of the terminal branches of the trees.

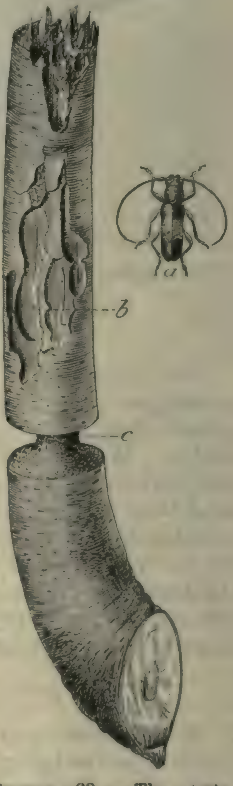

FIGURE 63. — The twig girdler: *a*, Beetle; *b*, larval mines in bark and outer wood; *c*, girdling work of adult

DESCRIPTION, SEASONAL HISTORY, AND HABITS

The beetles (figs. 62 and 63, *a*) range in length from one-half to five-eighths of an inch, the female being larger and more robust than the male. The long antennae or feelers of the male are considerably longer than the body, but those of the female are only a trifle longer than the body. The body is almost round, of a general grayish-brown color, with a rather broad, ashy band or belt extending over the middle of the wing covers. The thorax is about the same color as this band, but the head is more or less reddish.

The beetles, which begin to make their appearance in pecan orchards by the last of August or early in September, have very interesting habits. It is only the female that cuts off the twigs, but both sexes feed more or less upon the tender bark and wood of the tips. The branches apparently are girdled by the female in order that proper conditions may be provided for the development of the larvae, which are unable to subsist on wood containing sap. She does not make a complete circle at once, but cuts section by section until the entire twig has been girdled. The cut extends through the bark and well into the wood, leaving only a small portion of the heartwood untouched. (Fig. 63, *c.*) Usually the weight of the branch or the wind causes it to bend down or break off. The eggs, which are always deposited in the severed twigs, are white, oval shaped, and about one-tenth of an inch in length. They are laid during or after the cutting process, but never before the beetle has cut at least one section. They are inserted singly, beneath the bark, or slightly into the wood, near a bud scar or next to an offshoot. Usually they are deposited in the main stem of the branch, but if the branch is of good size some eggs are occasionally to be found in offshoots. After inserting the egg in the twig the beetle seals the puncture with a shiny, gummy substance, and then scars the twig for a short distance below the puncture. The number of eggs per twig may range from 3 to 40, although occasionally a severed branch without any eggs is found. The egg stage lasts three weeks.

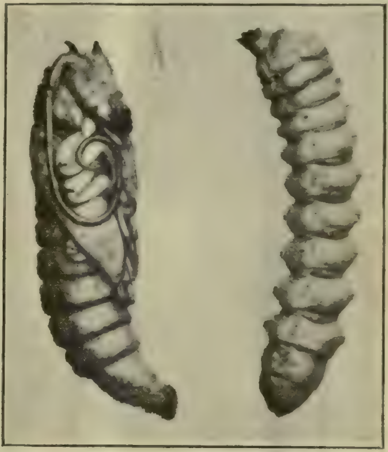

FIGURE 64.—Pupa and larva of the twig girdler: Pupa at left, larva at right. Enlarged 3 diameters

The larvae (fig. 64, right), which are whitish, legless grubs, make little growth during the fall or winter months, but with the advent of warm weather in the spring they grow very rapidly. In making their tunnels in the twig (fig. 63, *b*, and 65) they work usually toward the severed end and feed only on the woody fibers, leaving the bark intact. During the late spring or early summer most of the larvae make a few circular holes in the bark from which they cast out pellets of borings and excrement. Just prior to transformation to the pupa (fig. 64, left) each larva closes the end of its gallery with shredded shavings, making the pupation quarters, from which the adult emerges by gnawing a more of less circular hole in the bark. Usually only one year is required for development of the insect, though some larvae do not transform until the second season.

CONTROL

For the control of this pest all that is necessary is to gather the severed branches and burn them in the fall or winter. Care should be exercised to collect all branches from the ground, as well as those that may be lodged in the trees. By following this procedure all the eggs and larvae which would otherwise develop into beetles the following summer will be destroyed and the source of infestation eliminated. Pecan orchards that are growing adjacent to native hickory or persimmon trees will be found to be worst infested because this insect breeds abundantly in the severed branches of such trees. Under such conditions it would be well to destroy the severed

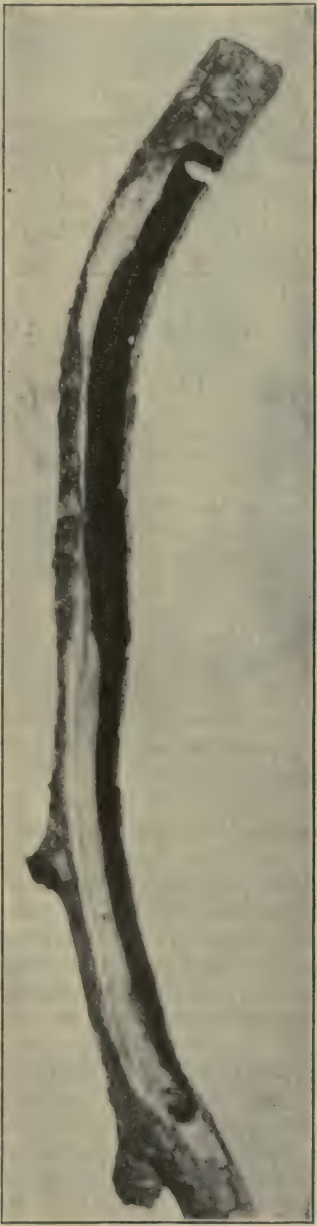

FIGURE 65.—Larval burrow of the twig girdler in cut-off pecan twig

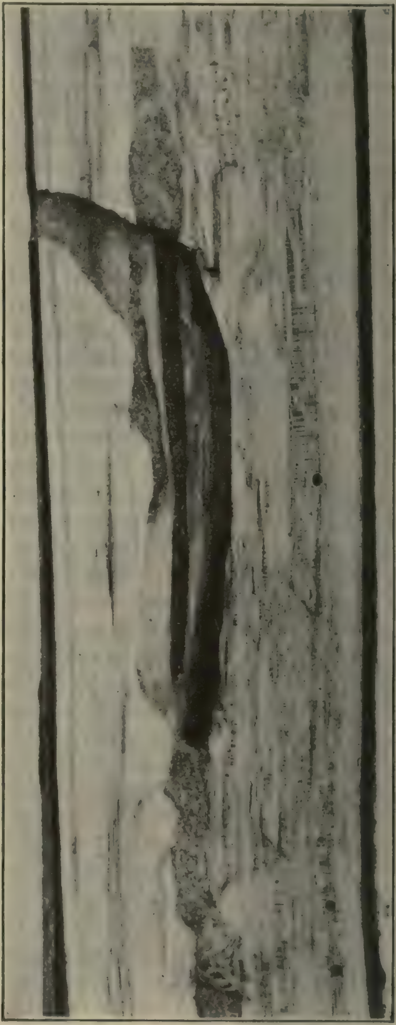

FIGURE 66.—Larval galleries of the belted chion in a pecan limb

branches from the hickory and persimmon trees immediately adjacent to commercial plantings of pecans.

THE BELTED CHION

The belted chion (*Chion cinctus* Drury), in its larval state, attacks the pecan and hickories and also other trees, forming long galleries in the trunk or limbs of weakened or dead trees. The galleries (fig. 66) are excavated to a considerable depth in the heartwood, in which they run in the same direction as the grain. The larva is a yellowish-white, round-headed borer, with brown head and black jaws. Upon attaining its full development it changes to a pupa within its gallery, and the adult beetle in emerging cuts a large circular exit hole through the bark. (Fig. 67.) The beetles make their appearance any time from March to September.

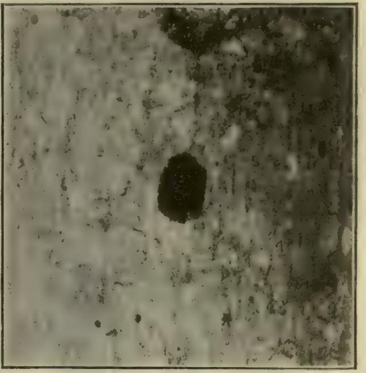

FIGURE 67.—Exit hole of the belted chion

The size of the beetles varies, the length being from two-thirds of an inch to a little more than an inch, and in the males the antennae, or feelers, are more than twice the length of the body. The color is light brown, usually with a short, oblique, dull band near the base of each wing cover, but in some specimens the bands are absent. Each wing cover bears two slender, conspicuous spines at its tip, and on each side of the thorax is a short prominent spine. (Fig. 68.)

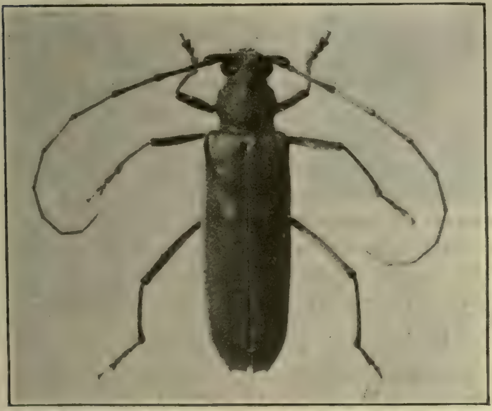

FIGURE 68.—Adult female of the belted chion. Enlarged 2 diameters

CONTROL MEASURES

About all that is necessary to prevent injury to the pecan orchard from this pest is to remove and burn dying trees and dead wood promptly, as it is well known that this species prefers to breed in such material.

THE OAK PRUNER

During the fall and winter, twigs or branches pruned by the larvae of the dark-brown beetle known as the oak pruner (*Hypermallus villosus* Fab.) (fig. 69) are to be found under pecan trees, as well as under oak, hickory, and various other forest, shade, and fruit trees. This insect does not especially favor the pecan, but seems to show a preference for various oaks. Although it occurs from New England westward to Michigan and southward to the Gulf States, it is seen too rarely in sufficient numbers in its extreme southern distribution to be ranked as a serious pest. In the North, however, serious injuries are sometimes caused by its pernicious pruning habits.

In the case of the twig girdler, the twigs are cut off by the female beetles, but with the oak pruner it is the larvae that amputate the branches. They do this by gnawing a circular groove in the wood, leaving only the bark intact. The branches so amputated are usually brought to the ground by the first strong wind, or, in some instances no doubt, by the weight of the branch itself. The end of the severed branch presents a smoothly cut surface (fig. 69), near the center of which will be seen a more or less oval opening plugged with fine shavings and sawdust. By way of contrast it may be stated that the end of the twig that is cut off by the twig girdler always presents at its center a more or less jagged surface.

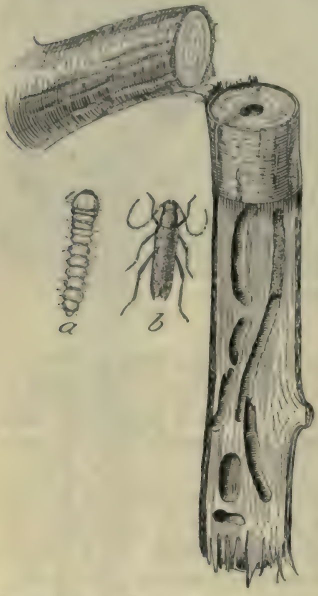

FIGURE 69.—The oak pruner: *a*, Larva; *b*, adult; (at right) cut-off twig, containing larval mines, hanging from stub of branch

The seasonal history is briefly as follows: The beetles (fig. 69, *b*) usually appear during the spring or early part of the summer, and the eggs are deposited in the leaf axils of the smaller twigs of living trees. Upon hatching, the larva feeds upon the wood immediately under the bark, but later it bores into the heartwood, where it makes an oval gallery several inches in length. (Fig. 69, right.) In the fall it cuts away the wood at the end of its gallery in such a manner that wind causes the twig to snap off. The larva (fig. 69, *a*) then proceeds to stop up the end of its channel with coarse shavings. In the larval burrow within the fallen branch the pupa is formed, either in the fall or early spring, and during the spring or early summer the beetle makes its appearance in the pecan orchards. Occasionally specimens of adults can be found in the pecan orchards as early as April.

CONTROL

The remedy for this species, like that for the twig girdler, consists in gathering the severed branches and burning them during the winter.

TERMITES [5]

Pecan trees, as well as other kinds of plants, are occasionally injured and sometimes killed by attacks of termites. (Fig. 70.) Pecan growers in certain sections are familiar with these pests under the name of "wood lice," the insects being so named because they often mine large galleries in dead wood and foundation timbers. On account of their underground habits and method of attack, termites usually escape notice until serious damage has been done, and are destroyed with great difficulty. According to reports the injury to pecan trees has been confined for the most part to seedlings 1 or 2 years old growing on recently cleared land. Sometimes young budded and grafted pecan trees are injured or killed by termite attacks, but in most, if not all, cases the orchards were set out on new land containing an abundance of dead wood.

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[5] *Reticulitermes flavipes* Kollar is the most widespread and abundant species of termite in the Eastern States.

As is the case with true ants, termites live in colonies, and because of their similarity to ants in appearance and habits the name "white ants" has come into more or less common usage. Termites only occasionally attack living trees, their principal and most serious damage being done to foundation timbers and woodwork of buildings. In cut-over woodlands they are often prevalent under the bark of dead logs or beneath the fragments of wood lying on the ground. On small seedling trees from 1 to 2 years old the taproot frequently is hollowed until little more than a shell of bark remains. (Fig. 71.) Termites usually gain entrance to the trees below ground, but their galleries may extend for an inch or so above the soil inside the heartwood. Apparently they attack grafted trees at a point where the graft has not healed over smoothly with the seedling stock.

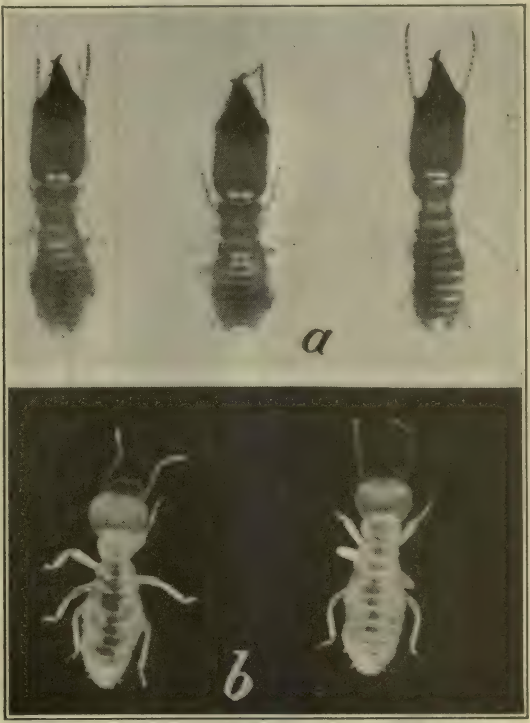

FIGURE 70.—Termites: *a*, Mature soldiers; *b*, mature workers

The affected trees as a rule do not show any indication of injury until they are damaged beyond recovery, and then they die very quickly, as is shown by the sudden wilting of the leaves.

CONTROL OF TERMITES

Because of the underground habits of termites it is difficult to apply a direct remedy to affected trees. Since they live in colonies and their nests are usually in the ground somewhere near the affected trees, it is important not only to kill the termites within the trees, but also to locate and destroy the inhabitants of the nests in order that permanent benefit may be obtained. Nests can perhaps be destroyed most easily by pouring carbon disulphide into them and then immediately packing the soil around the nest. This is a volatile liquid, and the gas, being heavier than air, will penetrate all recesses of the nest and cause the destruction of the termites. Since carbon-disulphide treatment is somewhat dangerous to plant life, care should be taken not to use very large dosages around the trees. It should never be applied closer than about 1 foot from the trunk.

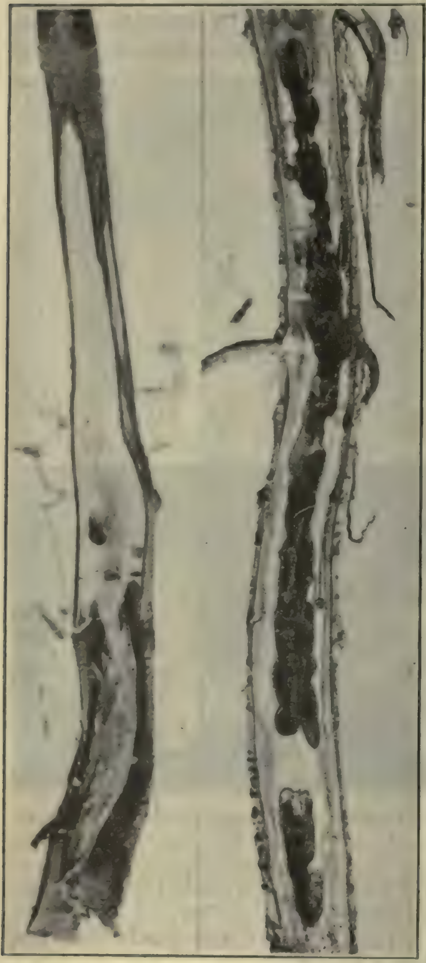

FIGURE 71.—Injury to roots of pecan nursery stock by termites

The injury to pecan nursery stock will be most serious on recently cleared land where decaying wood is abundant, as termites show a decided preference for such wood as a breeding place. As a nursery practice, for the prevention of attack by this insect, it is urged strongly that recently cleared land be avoided, but if used, all dead wood should be removed from the soil, and the growing of two or three farm crops on the land is advisable before planting the seedling nuts for the ultimate propagation of budded and grafted trees. The same advice holds true in case a young pecan orchard is to be set out, as prevention is a far more reliable method of fighting the pest than is the use of any direct remedy.

THE OBSCURE SCALE

The pecan is rather free from the attacks of scale insects, but the obscure scale (*Chrysomphalus obscurus* Comst.) has become a serious pest on both the native pecans and the cultivated varieties in Texas, Louisiana, Mississippi, and other Gulf coast districts. Besides the pecan, this insect attacks the chestnut, willow, oak, maple, hickory, grape, dogwood, wild myrtle, chinquapin, and hog plum. Occasionally trees are so badly infested that the trunks and branches are completely incrusted with this scale (fig. 72), and trees have been observed on which branches were killed. Frequently trees become so devitalized by the continued attacks of this insect that they become subject to the attacks of various borers, such as the flat-headed apple-tree borer, the cossid, and the shot-hole borers. Branches of pecan trees are easily broken off by the wind after the combined attacks of scale and borers.

The scale has its specialized mouth parts which it inserts into the tissues for the purpose of sucking the sap. Aside from the continual drain of sap from the tree, these scales often prevent proper functioning by becoming so abundant as to entirely cut off light and breathing surface from the branches and trunk of the tree.

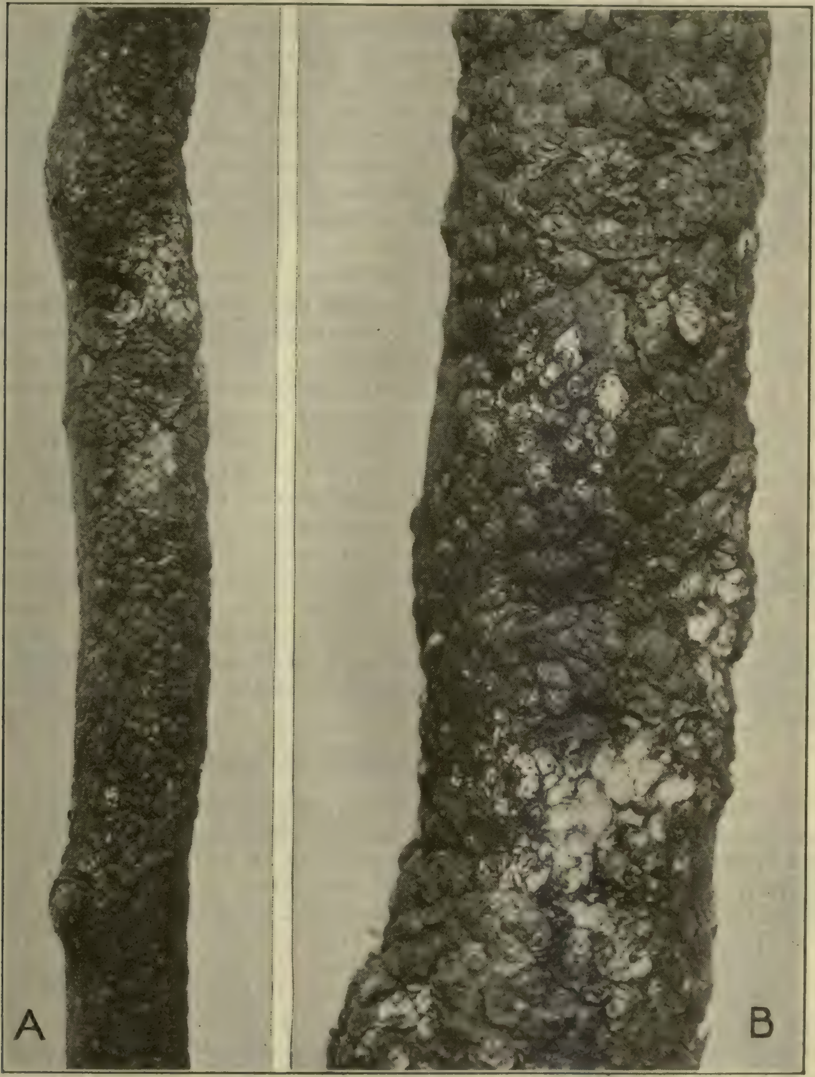

FIGURE 72.—The obscure scale on pecan twigs: A, Natural size; B, enlarged 2½ diameters

This insect belongs to a group called "scale insects" from the fact that their soft bodies are protected by scalelike coverings of a waxy material. In the case of this particular scale the covering is dark gray and approximately circular in outline. It agrees so well in color with the bark of the tree that it is exceedingly hard to detect, hence its name "obscure scale." When it becomes very abundant on a branch, however, as is shown in Figure 72, it is readily seen.

The newly hatched larvae or crawlers are very minute and pale yellow. They are born beneath the scale which covers the adult female, and after remaining a short time they emerge, but soon settle down on some part of the tree, such as the new growth or tender twigs. Upon finding a suitable place they insert their beaks into the plant tissue to feed and start the formation of their waxy scale coverings. From this time on the female is stationary, never changing her position. During her development she molts twice, the skins so cast going to make up the scale covering. The male is at first indistinguishable from the female, but later develops two wings and issues from beneath its covering as a very small, delicate insect.

SCALE CONTROL

In localities where this scale occurs the pecan grower should examine his trees frequently for it. For this purpose he should provide himself with a small magnifying glass. Where occasional trees in a pecan orchard become infested they should be given immediate attention so that the scale will not spread throughout the orchard.

The most practical time for killing this insect on pecan trees is during the dormant season, when one or two thorough applications with a standard lubricating-oil emulsion should be made, depending on the degree of infestation. The applications should be so timed as to be a month or six weeks apart. It can not be stated definitely at what strength lubricating-oil emulsion should be applied to obtain the maximum degree of control, but some measure of success may be obtained by using an oil emulsion, made according to the Government formula, at a strength of 3 per cent of oil by volume. In order to obtain this strength 9 gallons of the concentrate should be used to 191 gallons of water.

SOME FACTORS IN SUCCESSFUL SPRAYING

Growers who contemplate spraying operations and who desire satisfactory results should make careful plans a considerable time in advance. If it is the grower's intention to purchase a spraying outfit he should not wait until the very time it is needed. If a spraying outfit is already on hand, it should be overhauled with care some time before operations begin. This will afford plenty of time to send for new parts, if any are required.

As regards the spray outfit, the tank should be cleaned thoroughly and soaked so that it will not leak. The pump and engine should be carefully repaired and worn parts replaced. It is very essential to have the valves in perfect condition to secure the desired pressure, and there may be other parts about the pump as well as the engine that need repair. If the cut-offs leak they should be replaced or ground, and nozzles, rods, or guns should be carefully examined. It is always well to have an extra lead of hose so that spraying operations will not be greatly interrupted by a leaking hose.

Pecan growers who contemplate spraying should provide themselves with a suitable power outfit, equipped with a 15-horsepower engine, a pump capable of discharging 30 gallons per minute, and one which will maintain a pressure of 300 pounds. Spray guns are more generally used at the present time than rods for spraying pecan trees.

In spraying, the man on the ground as well as the man on the tower should aim to work half way round each tree down the row, spraying the other side of the tree on the return up the other side of the row. The spray should be applied to the tree in a systematic manner, preferably up and down, and with as little retracing as possible, to conserve materials. As to the quantity of insecticide required, successful results can not be obtained unless sufficient material is used to cover completely those parts of the tree where the insects are located. The quantity to be used will depend upon the density of foliage as well as upon the size of the trees. In spraying for any pest on pecan trees the work should be done thoroughly. For example, it is only when the leaves are hit by the insecticide that the leaf case-bearer larvae are killed; it is only when the twigs, branches, and trunks are sprayed that the scale on them is killed. In other words, thoroughness in spraying should be emphasized. Likewise the time for application is important and this should always be carefully ascertained before spraying.

SPRAY SCHEDULE FOR COMBATING PECAN INSECTS AND DISEASES[1]

Spray No. and time of application	Material	For control of—	Remarks
1. Dormant — November to January, inclusive.	Lubricating oil emulsion. Use 9 gallons of concentrate to 191 gallons of water.	Obscure scale	For light infestation make one application; for heavy infestation, two applications four to six weeks apart.
2 Immediately after pollination has taken place. The period when the tips of the small nuts have turned brown.	3–4–50 Bordeaux mixture plus nicotine sulphate 40 per cent at the rate of three-fourths of a pint to each 100 gallons of Bordeaux mixture. To control aphids on nonscabbing varieties use 40 per cent nicotine sulphate at the rate of three-fourths of a pint to 100 gallons of water plus 4 pounds of caustic potash fish-oil soap.	Scab and aphids	Both surfaces of leaves should be covered for protection against scab and to kill all aphids. For aphid control centers of trees should be sprayed as thoroughly as outer parts.
3. Three weeks after spray No. 2.	3–4–50 Bordeaux mixture	Scab	A good coverage of nuts is very important during this and all later applications. If webworms and caterpillars are abundant, add 1 pound calcium arsenate to each 50 gallons of Bordeaux mixture.
4. Three weeks after spray No. 3.	do	Scab, leaf blotch, and brown leaf spot.	Spray as directed in No. 2. If aphids are present in abundance at this time, add 40 per cent nicotine sulphate as in spray No. 2.
5. Three weeks after spray No. 4.	3–4–50 Bordeaux mixture; calcium arsenate 1 pound to each 50 gallons. Bordeaux, plus 40 per cent nicotine sulphate at the rate of three-fourths pint to each 100 gallons of the spray (add nicotine sulphate last).	Scab, leaf blotch, brown leaf spot, leaf case-bearer, and aphids.	Spray as directed in No 2.

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[1] This spray schedule is designed by G. F. Moznette, entomologist, and J. B. Demaree, pathologist, to meet conditions as they exist in southern pecan orchards.

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The Control of Moths in Upholstered Furniture

U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1655

The Control of Moths in Upholstered Furniture

THE ruination of woolen covers of upholstered furniture by moths is a source of great concern and loss throughout the United States. This bulletin is intended to acquaint the reader with essential facts favoring the development and control of moths as pests of upholstered furniture, so that he may guard against attack by them, which in too many instances is of such an insidious nature that the aesthetic value of furniture covers is destroyed even before the owner suspects the presence of insects. There seems to be no reason why woolen covers can not be maintained in good condition indefinitely, so far as moths are concerned, if owners will intelligently follow the suggestions for control discussed in this bulletin.

Washington, D. C.

Issued February, 1931
Revised August, 1931

THE CONTROL OF MOTHS IN UPHOLSTERED FURNITURE

By E. A. BACK, *Principal Entomologist, in charge, and* R. T. COTTON, *Senior Entomologist, Stored-Product Insect Investigations, Bureau of Entomology*

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INJURY TO FURNITURE WIDESPREAD

INJURY caused by the infestation of upholstered furniture by moths is widespread. (Figs. 1, 2, and 3.) No section of the country seems free from such infestations. Most of the losses sustained are due to neglect or to a lack of information concerning the life history and habits of the moths. Frequently these insects are discovered too late to prevent some defacement of the covers of the furniture.

Injury by moths is confined almost entirely to pieces of furniture having covers containing wool, such as wool tapestries and mohairs. The present popularity of these covers, because of their beauty and durability, need not be lessened because of the moth problem. Reputable furniture manufacturers and retailers, and storage concerns, have already gone to much expense to eliminate moths in furniture and to provide protection against infestation by them. If the housewife were as well informed a large share of the present-day losses could be prevented.

THE TWO KINDS OF MOTHS RESPONSIBLE FOR THE INJURY

There are two kinds, or species, of moths found more commonly in upholstered furniture in the United States. They are the two species of clothes moths known for generations as household pests—the webbing clothes moth (*Tineola bisselliella* Hummel) and the case-making clothes moth (*Tinea pellionella* L.). One or the other, or both, are present in practically every household. Most housewives are already familiar with them as pests of clothing, rugs, piano felts, and other woolen fabrics.

The moths of both species are small, buff-colored millers, with a wing spread of about one-half inch. They seldom fly directly to a light in a room, and remain flitting about it, as do so many moths, both small and large, which develop on outdoor vegetation, and for which a light has a great attraction. Clothes moths are usually seen flying in darkened corners and just beyond the range of the brightest rays of the lamp. They prefer darkness. They have imperfectly developed mouth parts, and could not feed upon fabrics if they wished. Their sole purpose in life is to lay eggs that develop into the worms, or larvae, which alone can cause destruction. The larvae hatching from the eggs are, when fully grown, whitish and about half an inch long. They spin cocoons, and in these they transform to the pupa, or chrysalis, stage. During this stage the insect changes to the adult, or moth. Thus each generation of clothes moths passes through four distinct stages, namely, the egg (fig. 6), the larva or worm (figs. 4, 5, 8, 10, 21, 23, and 24), the pupa or chrysalis (fig. 9), and the adult or moth (figs. 5, 7, 10, and 21). The reader should examine each illustration just referred to and read the accompanying legends for additional information regarding the general appearance of the different forms of the clothes moth.

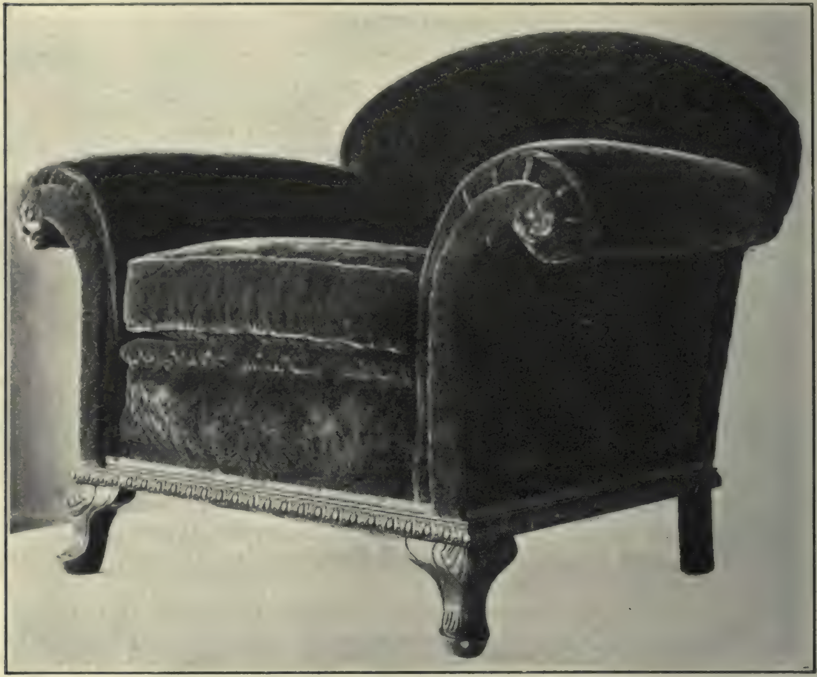

FIGURE 1.—Mohair-covered chair, showing bare spots developing in cover along the lower part of the side and in front beneath the cushion. On examination it was found that in front there was nothing between the cover and the framework but Spanish moss. Observe how general the damage is at this point. At the side the injury is always greatest low down, where the moths congregate in largest numbers between the cover and the framework, and where there is no cotton. The open spaces above, between the cover and the framework, form an excellent flying space for moths

BRIEF SUMMARY OF BIOLOGY

The biology of the two clothes moths affecting upholstered furniture is much the same. The following facts are taken from data obtained by the writers in their study of the webbing species.

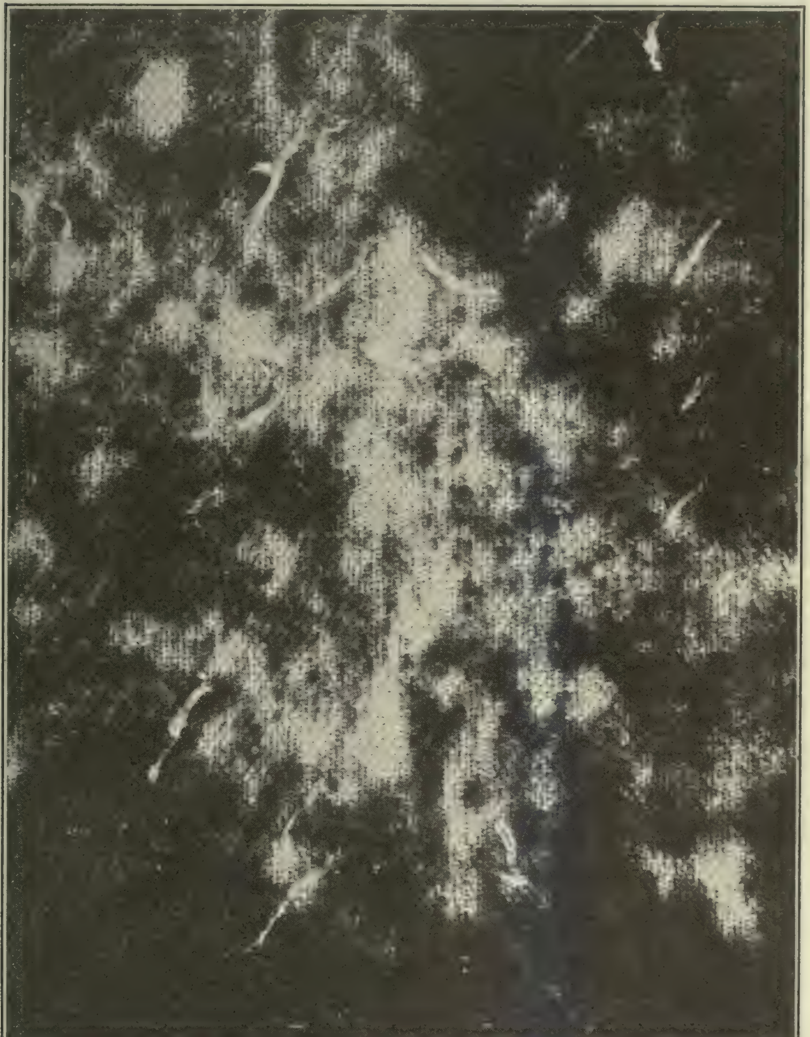

FIGURE 2.—Piece of mohair, showing, about natural size, a typical case of general surface feeding by clothes-moth larvae. Observe the scattering of moth webs

THE ADULT

The moth, or miller (figs. 5 and 7), as it is often called, is the parent insect. It does not grow in size, and, as has been stated, its only function in life is reproduction. Within a few hours after leaving the cocoon and after mating, the female moth begins to lay

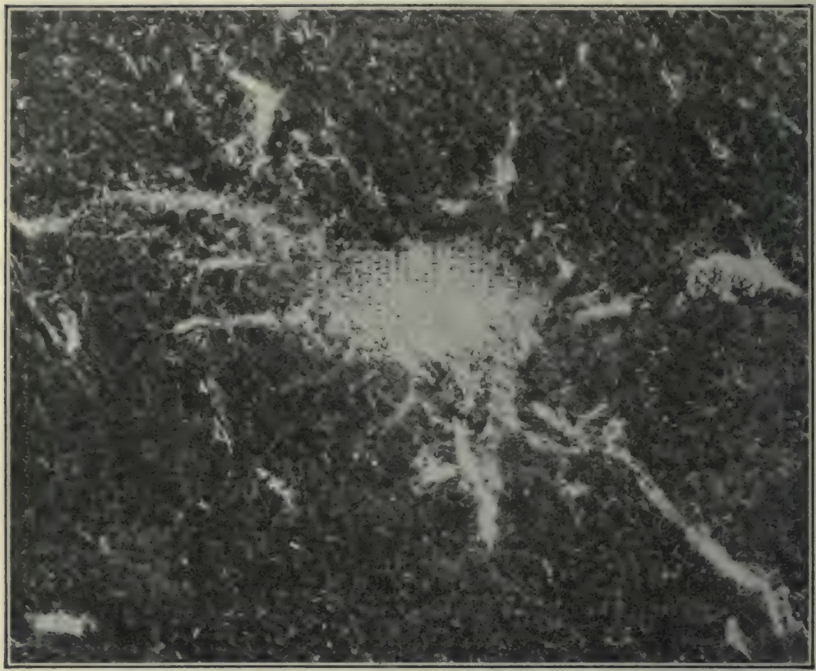

FIGURE 3.—Soiled spot on mohair cover, upon which moth larvae have concentrated their attack. An excellent illustration of surface feeding (p. 14), as indicated by the white feeding tubes or webs of the larvae which center on the soiled spot, the pile over which has been entirely eaten out. × 1½

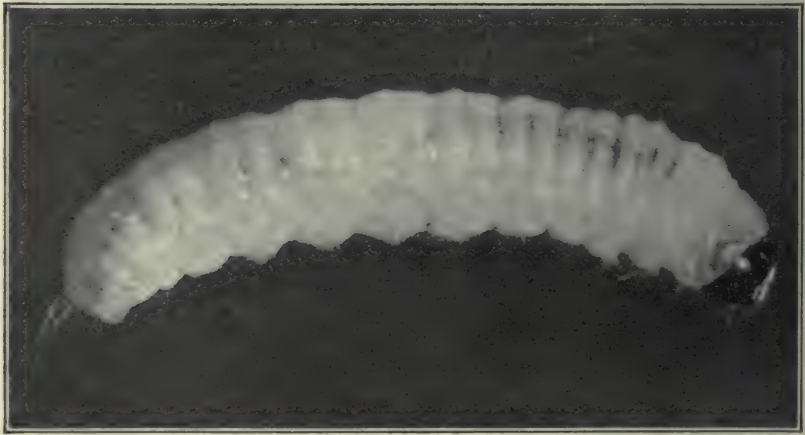

FIGURE 4.—Mature, or well-grown, larva of the webbing clothes moth. Larvae differ in size, but seldom exceed half an inch in length. They are chalk white, with a brown or blackish head. Enlarged 10 diameters

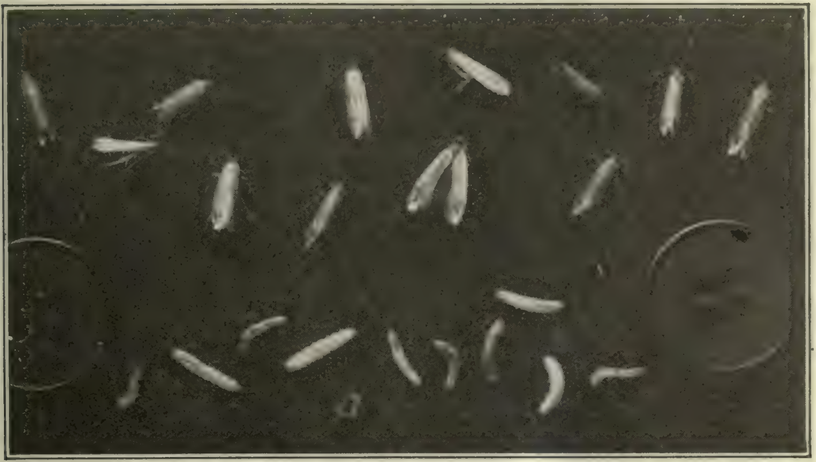

FIGURE 5.—Twelve adult webbing clothes moths and 11 worms, or larvae. All are photographed on a vest, the buttons of which are nine-sixteenths of an inch in diameter. Enlarged 1⅛ diameters

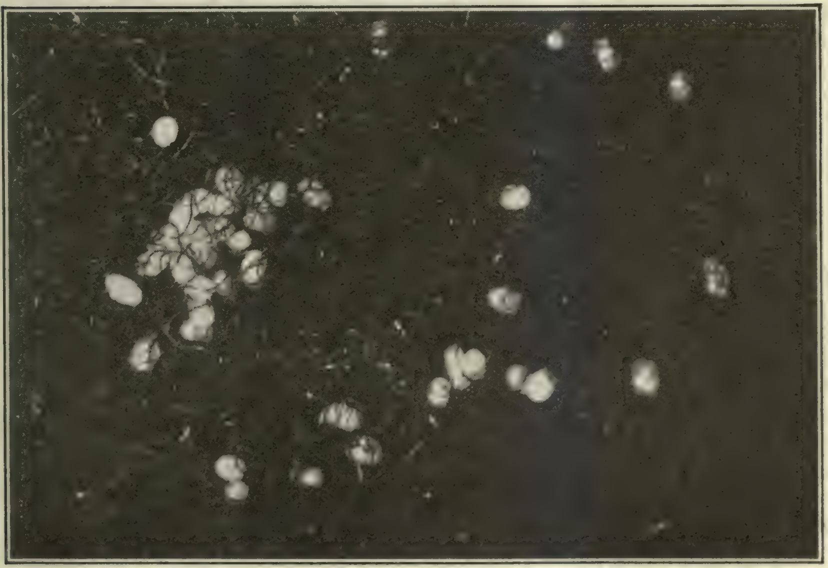

FIGURE 6.—Eggs of the webbing clothes moth, laid on a woolen cloth. They are hardly as large as the head of an ordinary pin, white, fragile, easily crushed by brushing. Although not glued to the fabric, many are laid well down in the nap, from which they can not be easily shaken. Enlarged 6 diameters

eggs. Although females may live for 30 or 40 days, most of them have a life of 10 to 14 days. Each female moth may lay a total of 200 to 300 eggs, although 100 eggs seems a more usual number. One moth laid 59 eggs in one day, but this number is above the average. The following three egg-laying records are taken as typical for warm weather when moths are kept in confinement: A female, emerging from her cocoon on August 2, laid 28, 12, 23, 5, and 2 eggs on August 3, 4, 5–6, 7, and 8, respectively. Another, emerging on August 1, laid 1, 28, 20, 31, 8, 5, and 1 eggs on August 2, 3, 4, 5–6, 7, 8, and 10, respectively. A third female, emerging August 7, laid 16, 15, 6, 3, 5, 6, 6, 3, and 2 eggs on August 8, 9, 10, 11, 12, 13, 14, 15, and 16, respectively. When a female ceases to lay eggs, her death follows, as a rule, within one or two days.

THE EGG

The whitish, soft, and very fragile eggs (figs. 6 and 17) hatch most readily in warm summer weather in from four to eight days. During colder weather hatching may not take place for three weeks. In well-heated buildings hatching does not require a much longer time than in warm summer weather. Eggs do not lie dormant and undeveloped through long periods of cold weather, as is supposed by some persons. If they do not hatch in a reasonably short time the embryo dies.

THE LARVA OR WORM

Of all the stages, the larva—the only stage in which clothes moths damage fabrics—is the most susceptible to outside influences upon its growth. The nature of its food, the temperature, and the humidity, all have pronounced effects. Sometimes, for no apparent reason, the larva may pass into a period of dormancy lasting some months, during which it will neither feed nor appreciably move about, but later it becomes active, feeds, and continues its growth.

When the semitransparent larva leaves the egg it is scarcely one-sixteenth of an inch long; yet it begins at once to feed and to grow. It is then so transparent that the color of its food shows through its body as a line extending along the center. When fully grown (fig. 4) it is opaque, white, and may be as much as half an inch long, although its size will vary with its environment and food supply. It is not possible to judge the age of a larva by its size, for some larvae at 15 months of age are very much smaller than others only 2 months old. The great variation in the length of time larvae require to become well developed is one of the peculiar things about clothes moths. The shortest definite time for development recorded by the writers is about 40 days, at a temperature of 85° F. This is probably about the shortest time in which the larva can become full grown under favorable summer conditions of warmth and humidity. From this minimum the period of growth may be greatly extended, even to include several years, as is indicated by the facts given under the heading "Duration of Development" (p. 7).

THE PUPA

The pupal or chrysalis stage (fig. 9) is usually of short duration, lasting from about 8 to 10 days in summer to 4 weeks in winter, in steam-heated apartments. The insect does no harm in the pupal stage; it merely transforms from the larva to the adult, or moth.

DURATION OF DEVELOPMENT

As will have been gathered from the foregoing, each clothes moth passes through four stages in its life. The adult moth lays the eggs from which the larvæ hatch. The larva, in turn, spins a cocoon and changes to the pupa, which finally develops into the adult, or sexually mature moth. The total time required for the insect to pass through this so-called "life cycle" is of unusual interest and importance to furniture owners who are attempting to solve the problem of responsibility for infestation. It is unfortunate that there is not more uniformity in the developmental periods, for such uniformity would simplify problems involving responsibility. The following definite records of development of individual moths are taken from the files of the Department of Agriculture.

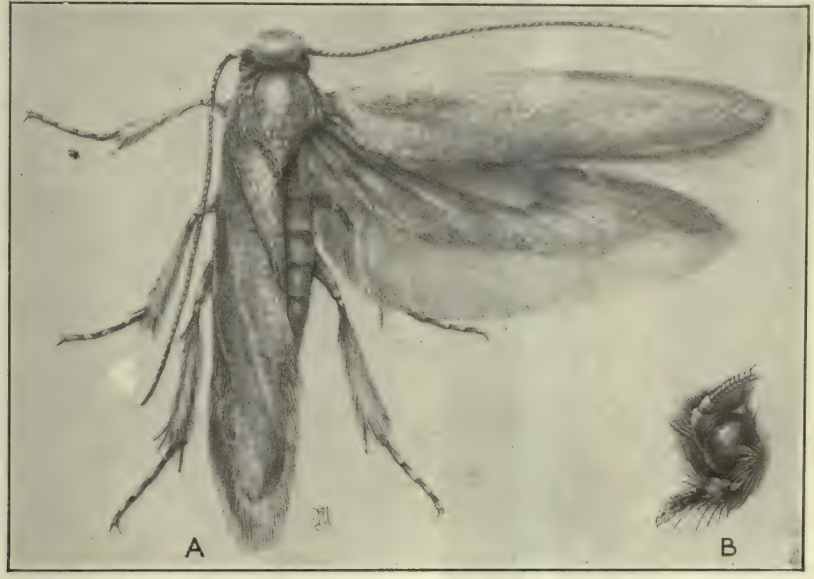

FIGURE 7.—A, female webbing clothes moth, enlarged 8 diameters. She can place eggs down in the nap or pile of fabrics and in crevices of furniture by means of her ovipositor, which can be extended much as can a telescope. The ovipositor, concealed by the folded wing, is at the tip of her body. B, side view of head

The shortest period of development recorded lasted 55 days, from the day the egg was laid to the day the moth left the pupa. This egg was laid January 24, 1924, the larva hatched from the egg January 30, and the adult emerged from the pupa on March 20. This specimen was held in an incubator at an even temperature of 85° F. Another individual developed from an egg laid January 31, 1924, and became an adult July 24, or 175 days later. Many other moths developing from eggs laid between January 24 and January 31, 1924, held at the same even temperature of 85° F., and fed the same food, matured as adults at intervals ranging between 55 and 175 days after the laying of the eggs.

The longest period of development known to the writers extended from August 24, 1922, when the egg was laid, to June 12, 1926, when the adult emerged, that is, nearly four years. Many other eggs, laid in August, 1922, developed into moths at various times during the interval from March to August, inclusive, 1923. The interesting specimen just mentioned as hatching from the egg laid on August 24, 1922, and maturing as a moth in June, 1926, fed voraciously until winter set in, and fed again during the summer of 1923, but by September 14, 1923, had protected itself by building a cocoon called by the writers a "resting cocoon." In this cocoon it remained quiet, without food, until January 15, 1926. When examined at that time, the larva was found to be still in the cocoon. It was not examined again until February 5, when it was found to have left the cocoon and to be feeding normally and giving every indication of being thoroughly healthy.

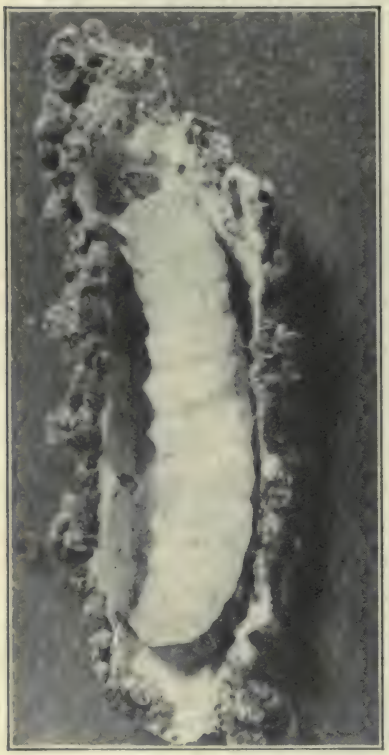

FIGURE 8.—Cocoon of webbing clothes moth, sectioned to show the well-grown larva about to transform to the pupal stage. Natural length of larva about one-half inch. Enlarged 7 diameters

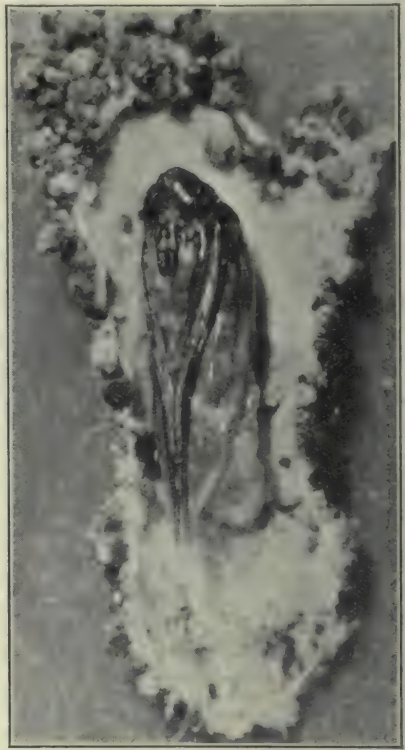

FIGURE 9.—Cocoon of webbing clothes moth, sectioned to show a pupa. It is from this pupa that the moth develops and emerges. Observe pellets of frass (p. 23) which the larva wove into the cocoon. Enlarged 7 diameters

To those interested in and concerned with the biology of clothes moths, the variations in the length of the life cycle from 55 days to nearly 4 years is of practical interest. Special interest centers in the minimum period for development and in the ability of the worms to spin for themselves cocoons in which they remain inactive.

Even when given the best of food conditions and normal humidity, most individuals reared by the writers required from 65 to 90 days as a minimum for development when entire development occurred during the summer under normal conditions. If eggs are laid in August, most of them will become adults in the course of the following April, May, June, and July. In protecting furniture the minimum period for development must be considered as most important.

The peculiar ability of the larva to go into a resting cocoon and refrain from eating for long intervals results in tremendous variations in the period of development that seem entirely independent of conditions of food, temperature, and humidity. This resting, or dormant period, may be very short; 8 to 11 months is not unusually long, but the one of at least 29 months referred to above is the longest observed by the writers. Not many larvae of a total number kept under observation become quiescent under conditions of warmth and humidity, when their companions are feeding actively. This state of quiescence may be abruptly terminated by a condition that irritates or disturbs the larva.

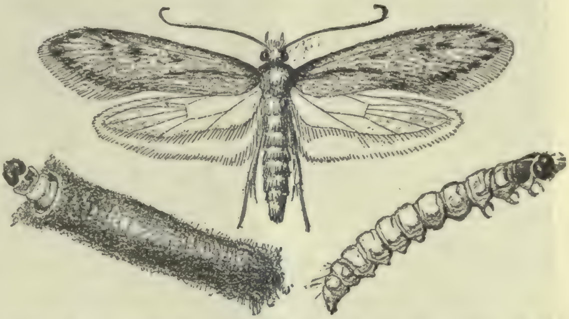

FIGURE 10.—The case-making clothes moth: Upper, adult moth; right, larva; left, larva partially concealed in the case (Riley). Observe the dark spots on the buff-colored fore wings; these distinguish the adult of the case-making clothes moth from that of the webbing clothes moth, the wings of which are uniformly buff colored. All enlarged 6 diameters

THE FOOD OF CLOTHES MOTHS

NORMAL FOOD

It is well known that the larvae of clothes moths feed on materials of animal origin, such as hair, fur, wool, and feathers, and on all things into the manufacture of which these enter. Other animal products less often thought of as food for moths, but often very important from the standpoint of keeping alive infestations in buildings, are casein, dried excretions from animals, and the desiccated bodies of all kinds of insects and of bats, birds, rats, and mice. Foods sometimes not thought of by the housewife are piano felts, and the fur of pets and the woolen lint lodged in floor cracks, behind baseboards, or carried by air currents to inaccessible places in partitions.

As previously stated, the adult clothes moths take no food during their brief lifetime; in fact, their mouth parts are so imperfectly developed that eating is impossible.

MATERIALS NOT USED AS FOOD

Moth larvae do not feed upon materials of vegetable origin. Linen, cotton, and rayon goods, wrapping paper, and vegetable fibers are not eaten. Natural silk, although not vegetable, is seldom eaten. In rare instances the larvae may eat holes in paper or in cotton and linen goods, but this, when it occurs, usually results from excessive infestation in close quarters, or the cutting of the goods by the larva that it may obtain bits of material to build into its cocoon. For all practical purposes moth larvae do not feed upon vegetable products.

THE PARTS OF UPHOLSTERED FURNITURE EATEN BY MOTH LARVAE

In upholstered furniture the larvae of clothes moths feed upon the woolen fibers in covers (figs. 1, 2, 3), the feathers in cushions (fig. 12) and pads, and to a limited extent upon hair fillings (fig. 13).

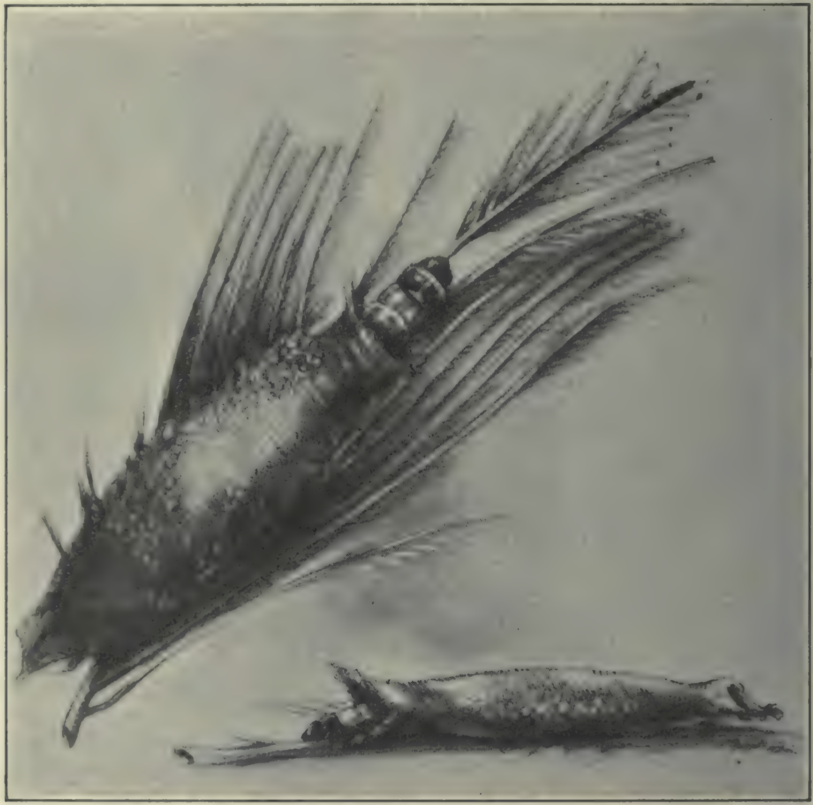

FIGURE 11.—Two case-making clothes-moth larvae, mostly hidden within their portable cases. These cases are carried about by the larvae wherever they go. Since it has six legs on the three body segments just back of the head, the larva has no difficulty in pulling the case about. When feeding (in this instance, upon a feather), the larva crawls partly out of the case, as shown. When disturbed, the larva withdraws quickly into the case, and the flaps at the exit are quickly pulled shut, and no one would suspect that a live insect was within. Enlarged 6 diameters

In advanced cases of infestation the dead moths and larvae resulting from the high rate of mortality suffered by moth colonies are important sources of food.

IMMUNITY OF VEGETABLE MATERIALS USED FOR UPHOLSTERING

Contrary to the belief of many, vegetable products used in upholstering furniture are not fed upon by larvae of the clothes moth. The most commonly used vegetable products are cotton batting, burlap, cotton and linen fabrics, Spanish moss, flax straw or tow, palm fiber, and sea moss. Whenever any of these products, used for padding the furniture, come in direct contact with a woolen cover, the larvae take advantage of their more or less porous nature to secure a safe retreat in which to molt and rest when not feeding upon the wool in the cover.

Under such circumstances the worms may fill the moss, tow, or other material so full of their webs and excrement and so many dead larvae may be found in it as to make it appear as a food of the larvae. (Fig. 14.) If bales of any of the vegetable materials here mentioned were set in warehouse by themselves they would never attract clothes moths.

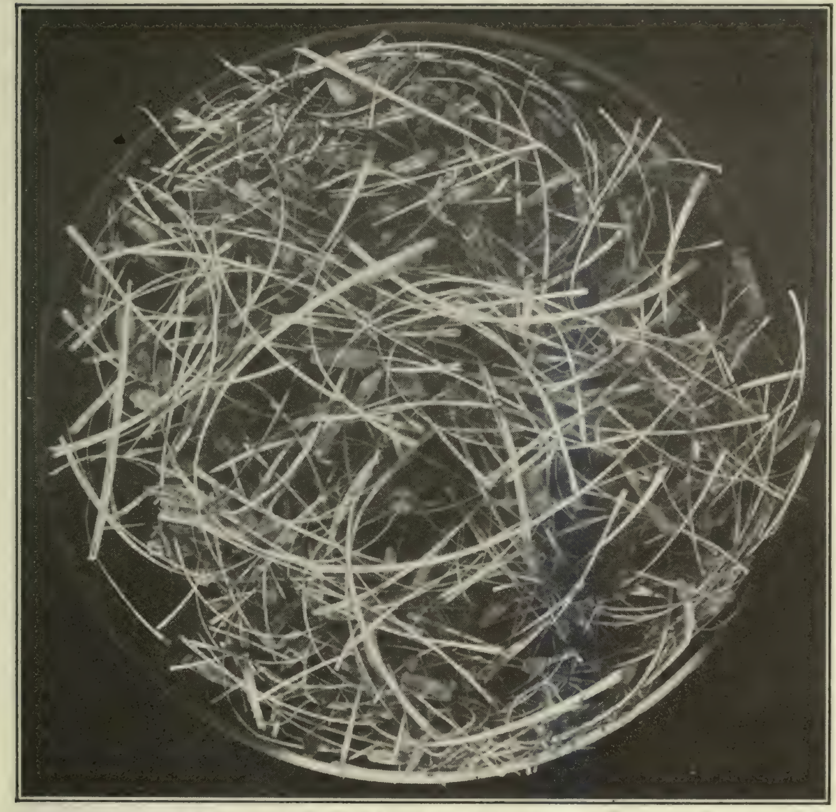

FIGURE 12.—A dish (natural size) showing many cases of the case-making clothes moth, together with all that is left of a handful of feathers taken from a cushion of a divan. This cushion had been reduced to a mass of dead insects, moth excrement, and feather ribs

HOW MOTHS GET INTO FURNITURE

Upholstered furniture, when built by reputable firms, is free from infestation by moths. Great care is taken to use only insect-free materials, and the product is above suspicion. Since clothes moths are universal pests, furniture with woolen covers is likely to become infested if it is exposed in any room where moths are present. Although moth larvae crawl, it is not believed that they crawl into upholstered furniture from other house furnishings. Infestation comes about from the eggs laid by the adult moth or miller, which finds its way to the furniture. The female moth, in seeking a dark, secluded place, may crawl between the cushions and the back or sides of the chair or divan, and thus find herself in the open spaces usually present at the sides and back of furniture. In these spaces, or among the springs, she finds a very satisfactory, protected place in which to lay her eggs unseen and unmolested by brush or vacuum cleaner. (Figs. 15 and 16.)

More often the female moth deposits her eggs here and there on the cover. Figure 17 is a diagrammatic drawing indicating how she uses the telescopic ovipositor to place eggs down among the fibers of the tufts of pile. The moth may also tuck her eggs into the seams and the crevices formed by the edges of the pieces of the cover where they are tacked to the frame. Unless the bottom of the furniture is thoroughly ceiled with fabric the moth may enter at openings where the legs join the frame, and lay eggs at will among the springs.

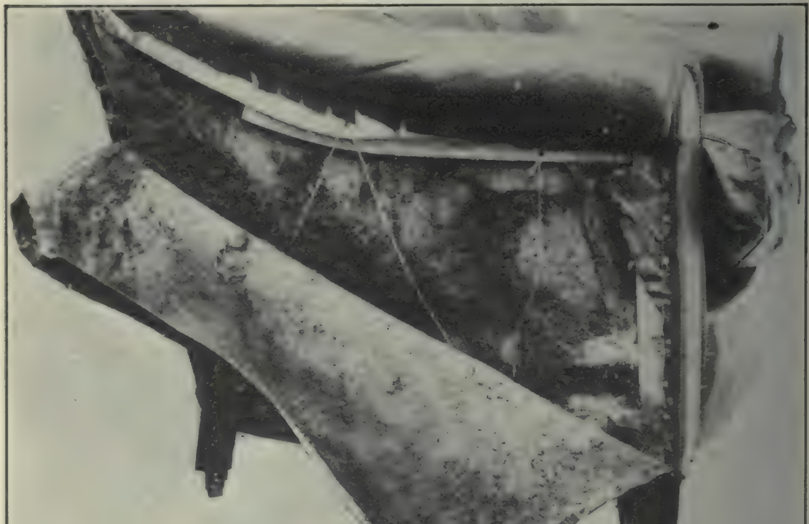

FIGURE 13.—End of a leather-covered couch, with end pieces laid back to show moth webbing in the curled hair and the many moth cocoons attached to the inner surface of the leather. Each cocoon is about half an inch in length. Such a piece of furniture may produce many moth millers

TWO METHODS OF ATTACK UPON WOOLEN COVERS

Once the eggs have been laid, they hatch within a very few days (p. 6). The newly hatched larvae are capable of squeezing through incredibly small openings. They are very active and crawl readily in an attempt to get away from the brightest light. In seeking a suitable place to feed they either spin their first webs in the very

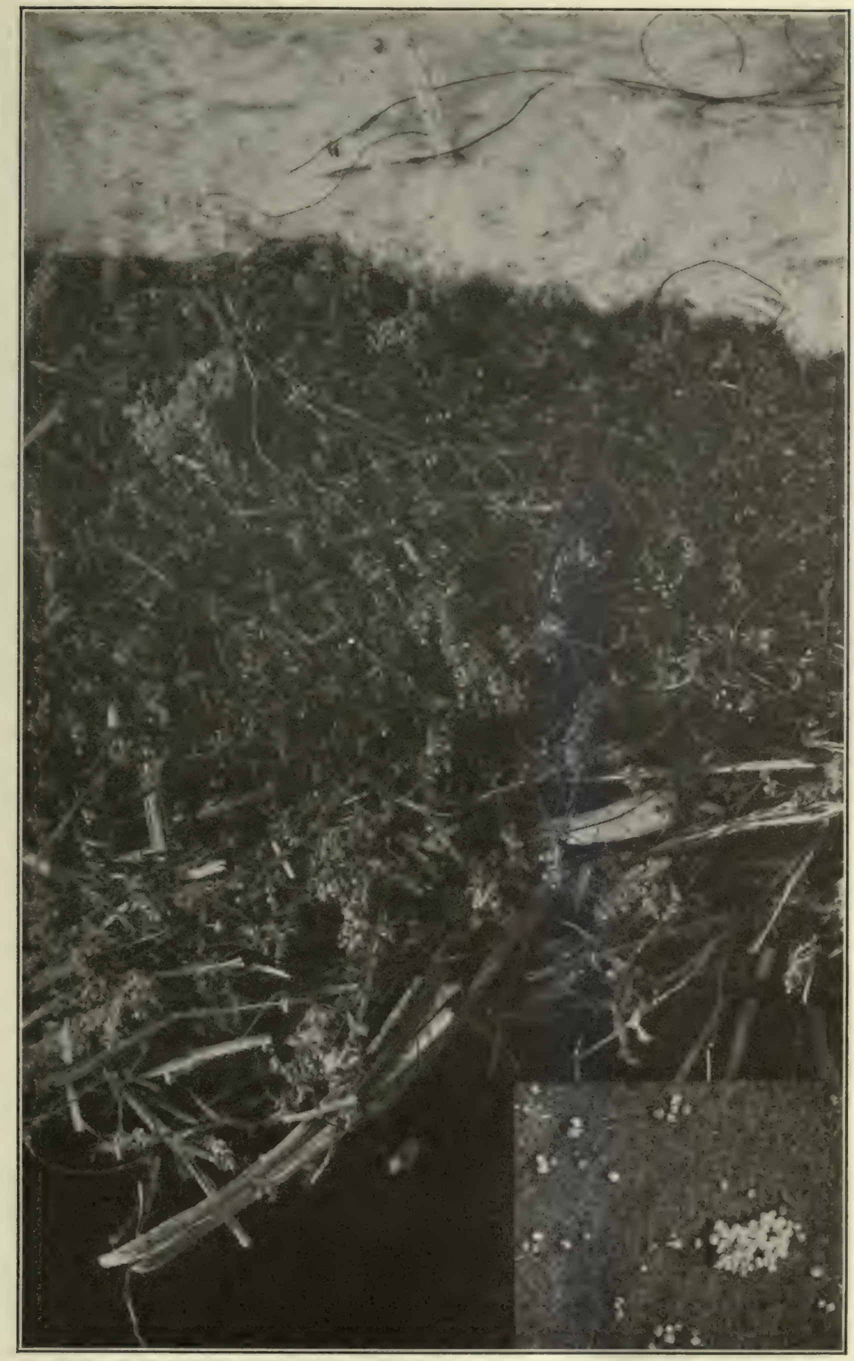

FIGURE 14.—Portion of pad from back of upholstered chair. Observe the layer of cotton batting, the Spanish moss, and tow. Where the moss and tow come in contact with the woolen cover they are filled with the excrement and webbing of clothes-moth larvae. Covers in contact with moss, hair, tow, palm fiber, or any other similar material, are apt to become damaged. The insert shows the gritty or sandlike pellets of larval excrement, magnified about 2 diameters

inconspicuous spaces between the rows of pile and against the upper side of the warp, or they are successful in working their way into the inside of the furniture by way of the seams, the spaces between the cushions and the sides or the back, or, in some instances, through the mesh of the warp itself. And, according to whether they stay on the outside or get beneath the cover, their feeding results in two types of injury, known respectively as "surface feeding" and "feeding from within" and beneath the cover.

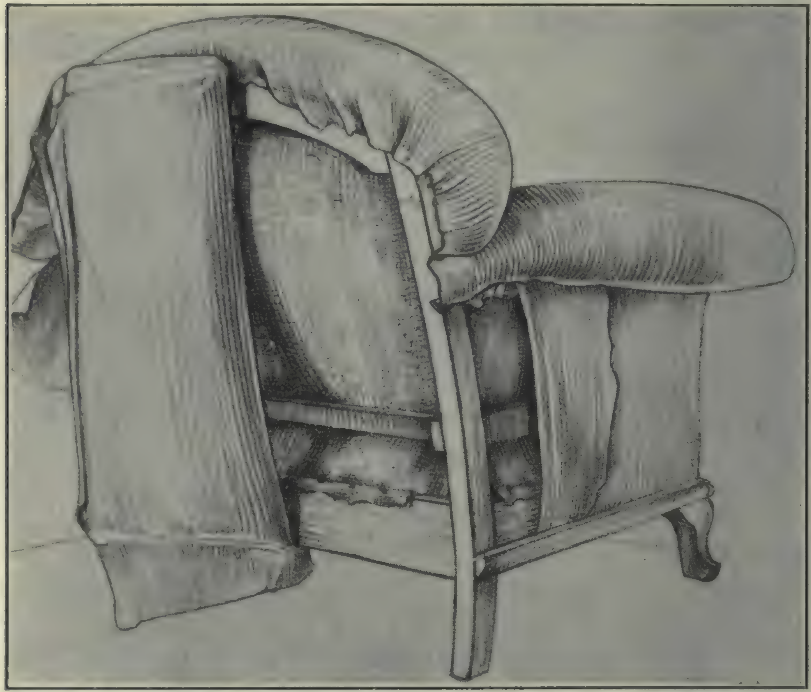

FIGURE 15.—Overstuffed furniture of the type illustrated here is ideal for the development of clothes moths. The newly hatched larvae crawl into the furniture at various points where the covering is tacked on, or even by forcing their way through the covering itself, or through the spaces between bottom, sides, and back. Once inside, the insect finds in the abundant food material and the large open spaces of the sides and back and about the spring coils conditions permitting increase, and generation after generation can multiply without any adult moths leaving the furniture. If larvae spin up for transformation between the pieces of covering, the adults may succeed in leaving the chair. Large numbers lay their eggs within and about the open spaces, from which the developing worms may migrate

SURFACE FEEDING

In the case of surface feeding the larvae remain on the outside of the covers, where they can be seen and reached. They crawl down between the rows of pile and there build elongated silken tubes of a whitish color, which they use as passageways. Although they attempt to conceal both themselves and these tubes by spinning into the webs some of the remnants of the fabric upon which they feed, they are not entirely successful; during early larval life the tubes retain their whitish color and a careful search reveals them. Figure 18 illustrates numbers of tubes spun on the exposed underside of a mohair warp. The tubes in mohair covers usually follow the rows of pile, as indicated in Figure 20. Other views of surface feeding

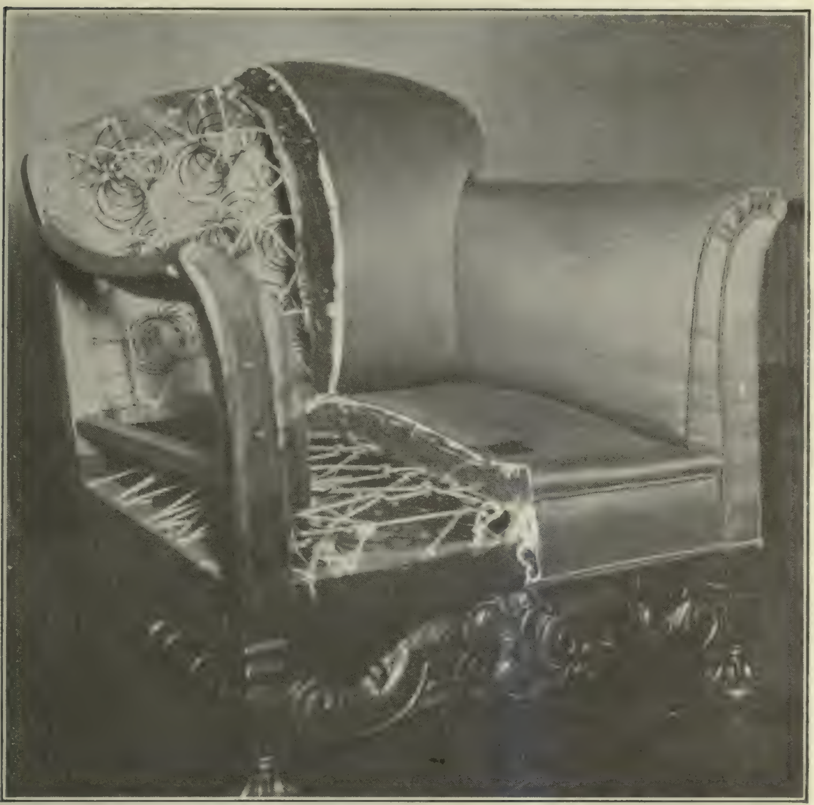

FIGURE 16.—Type of construction which will assist in preventing injury to furniture resulting from feeding of moths from beneath the cover. Observe that the chair has been formed with a stout cotton cover over which the outer cover will be applied; observe also the use of cotton batting at the front and everywhere beneath the cotton or inner cover. Although moths might get into the spaces about the springs and from there pass through the burlap covering them, into the moss or hair, they can not eat their way through the unbroken layers of cotton batting

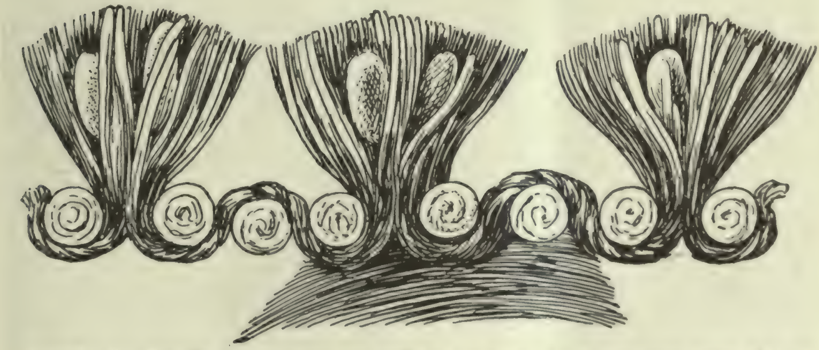

FIGURE 17.—Clothes moths often lay eggs in the pile of the furniture cover, as indicated in this drawing. The young larvae on hatching either force their way into the furniture through the warp of the cover, or enter it through points even more accessible to them. Of course many will feed on the pile tufts themselves if they are not molested by brushing or house cleaning. Enlarged 25 diameters

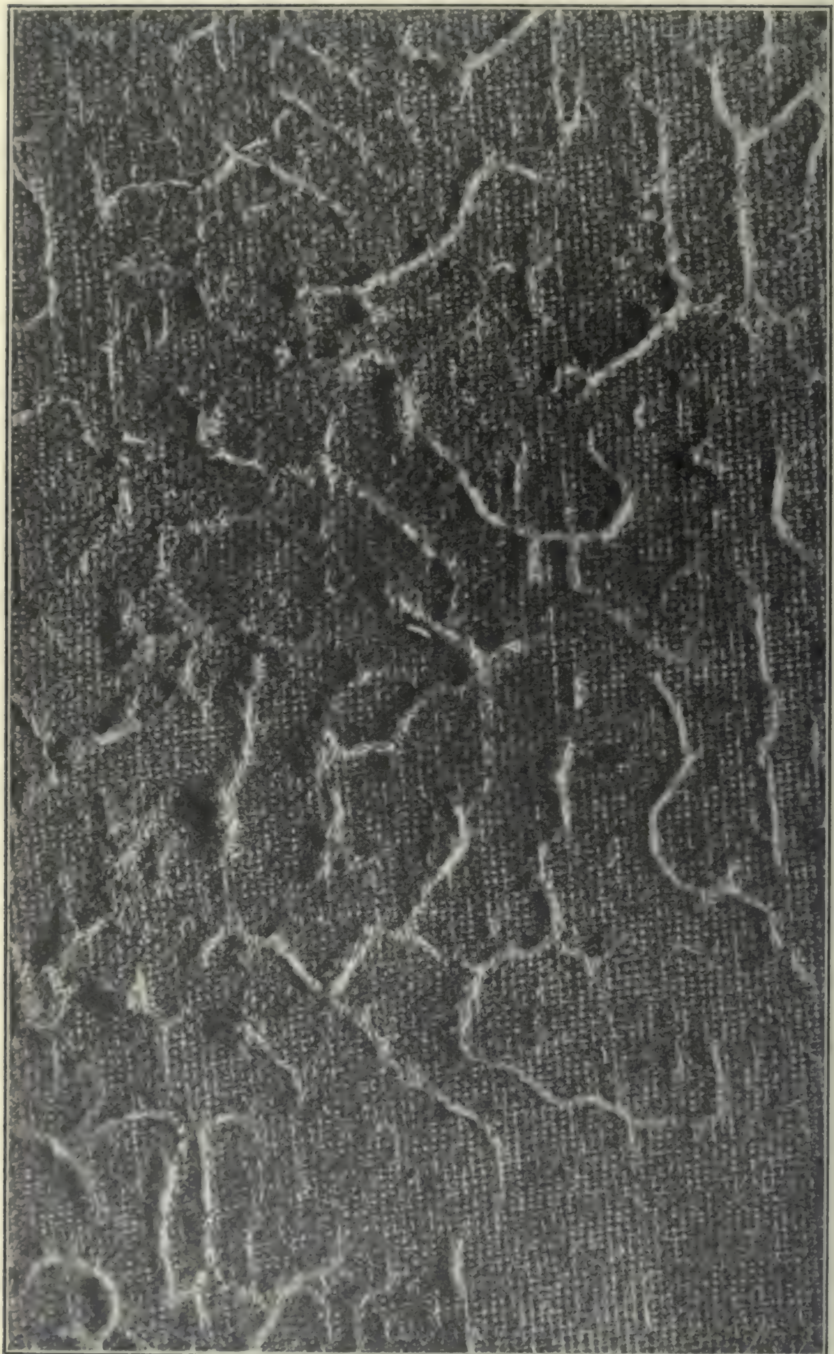

FIGURE 18.—Many feeding tubes, natural size, built by the larvae of the webbing clothes moth on the back of mohair from the side of a chair built as indicated in Figure 15. The larvae crawl back and forth through these tubes, protruding their heads to feed when they wish upon the wool in the cover, but more often extending the tubes as they need more food

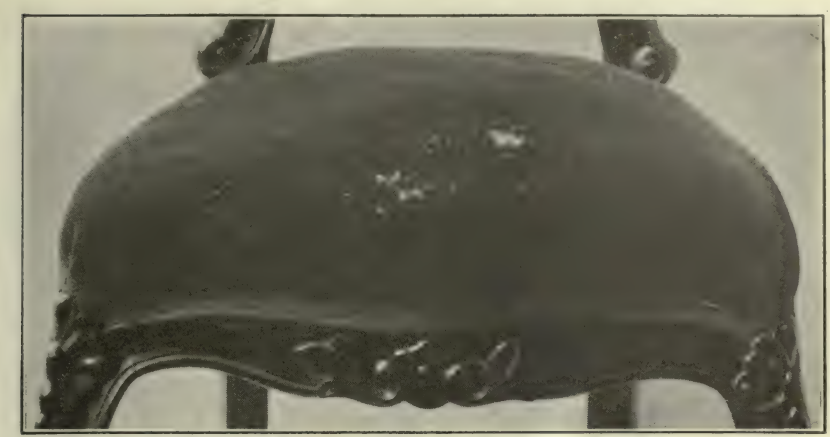

FIGURE 19.—Side chair, the seat covering of which is damaged by surface feeding by larvae of the webbing clothes moth. Furniture upholstered with woolen covers is likely to be injured by surface feeding, especially if covered with slip covers and left standing in living rooms, or if left unprotected in storage

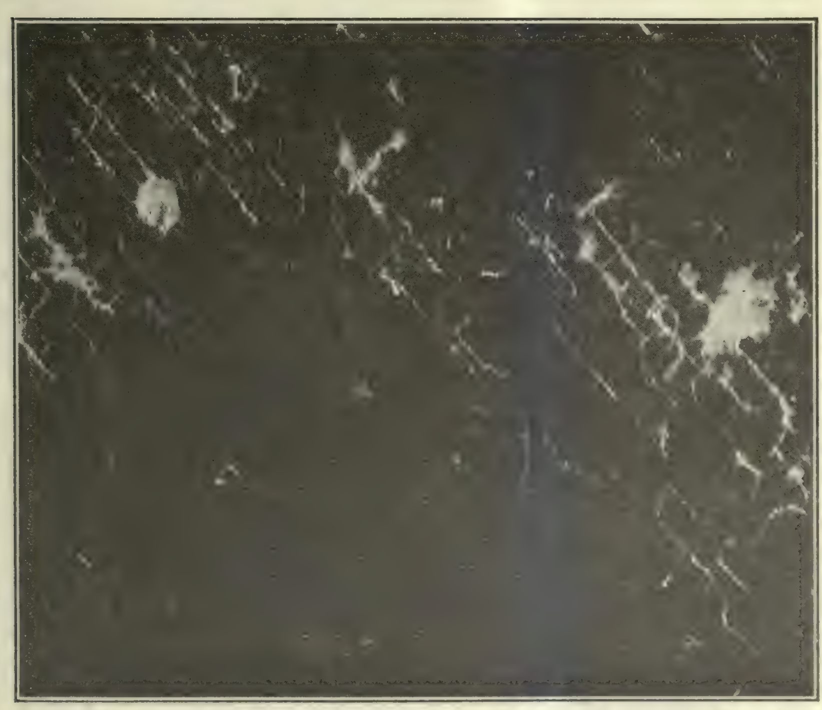

FIGURE 20.—Portion of cover of the chair shown in Figure 19, photographed natural size, to show the usual indications of surface feeding which is still, for the most part, confined to the spaces between the rows of pile. Notice that the larvae build their white silken tubes between the rows of pile. From these tubes the larvae browse upon the threads of the pile, cutting them off above the warp foundation

are shown in Figures 2, 3, and 19. If one were to cut across the cover itself the larval and pupal cocoons might be revealed clearly as in the diagrammatic sketch shown in Figure 21 and in the actual photograph presented in Figure 22. Sometimes as larvae become older they build their feeding tubes over the top of the pile, as is shown in Figures 2 and 3. Surface feeding occurs chiefly on the portions of the cover that are turned against the wall, are behind pillows, or in other shaded spots, or anywhere on the furniture, provided the room is seldom used or is closed for the summer or the season.

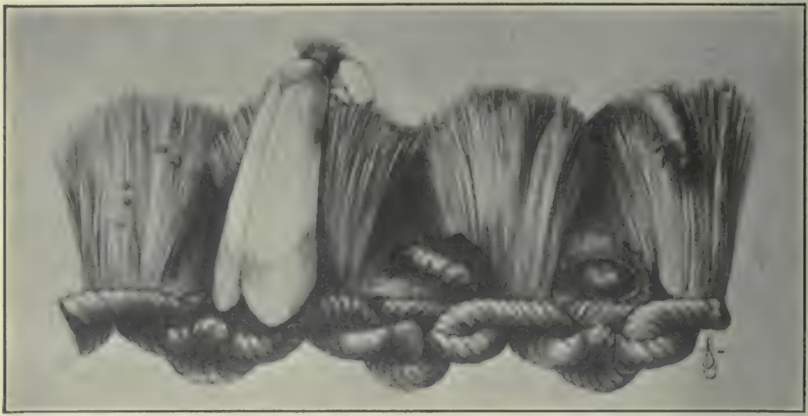

FIGURE 21.—Injury to carpet by the webbing clothes moth: Eggs faintly shown against tuft of mohair pile at left; adult moth on next tuft, to the right of which, below, is shown a larva eating at base of the third tuft; in the last space is a cocoon with the end cut away to expose the pupa within; a larva is shown crawling over the top of tuft at extreme right. Enlarged 5 diameters

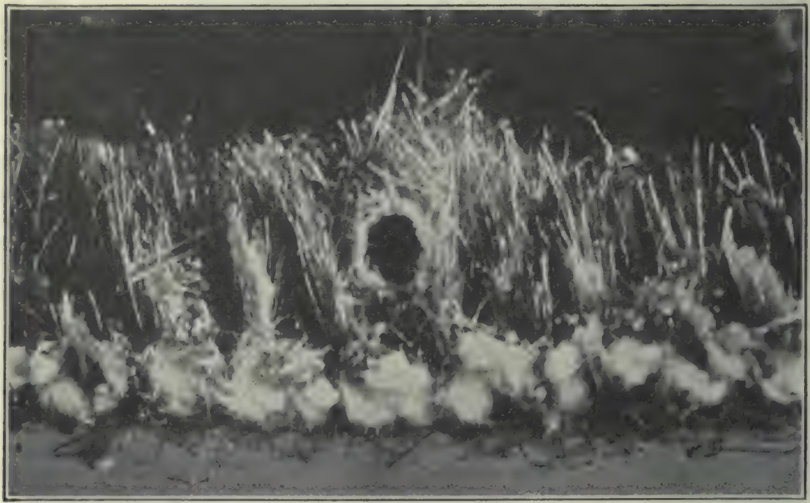

FIGURE 22.—Cross section of mohair cover, revealing a feeding tube of a larva of the webbing clothes moth. These tubes are usually close to the warp when the larvae are very young, but as the larvae grow older the tubes extend everywhere and are sometimes even built on the surface of the mohair, as shown in Figures 2 and 3. Enlarged about 10 diameters

When mohair has been injured by surface feeding the back side of it appears normal. The pile is eaten off just above the warp. An examination under a hand lens will reveal whether or not the injury is the result of surface feeding.

FEEDING FROM BELOW THE COVER

While surface feeding, or feeding on the outer side of the furniture cover, is always evident to anybody who will look for it carefully, feeding from beneath the cover is of a most insidious nature. Like a thief, the larva works unseen and usually unsuspected. It is not until the pile begins to fall out in irregular patches when the furniture is brushed or otherwise cleaned that the owner suspects that something is wrong. In Figure 1 is shown the usual form of injury. The pile falls out, as indicated on the front beneath the cushion, and on the side near the bottom. As the vegetable warp of mohairs is usually different in color from that of the woolen pile, the furniture assumes a spotted appearance and its aesthetic value is destroyed.

What actually happens is that wherever the larvae gain access to the underside of the woolen cover they begin to eat the woolen threads where they pass beneath the warp, which, being of vegetable origin, is not eaten. In Figures 23 and 24 is shown in a diagrammatic way how the worms form their tunnels beneath the cover and cut the woolen threads so that the tufts of pile fall out.

When woolen mohair is stretched over an opening, as at the sides and back of certain types of upholstered furniture, the moth larvae have an excellent opportunity to build their feeding tubes at will over a flat surface. In Figure 18 is shown on the natural scale an array of these tubes. Each tube, which in cross section would appear much as in Figures 21 and 22, may shelter a growing worm which makes an opening in the tube when and where it will in order that it may browse upon the woolen threads.

THE VALUE OF COTTON BATTING IN PREVENTING FEEDING FROM BENEATH THE COVERS

In much upholstered furniture in American dwellings pads of vegetable fibers, such as flax tow, Spanish moss, and palm fiber, and sometimes curled hair, cover the springs of the back and the arms. These pads are then covered with a layer of cotton batting before the fabric cover is applied. It has been found that this layer of cotton batting is of great importance in warding off, or entirely preventing, much of the injury caused by worms feeding beneath the surface. It has been estimated that fully 90 per cent of all well-defined areas of feeding, where cotton backs the cover, are due to faulty workmanship at the factory, and should be directly charged to the upholsterer. For example, in the winged chair shown in Figure 25, feeding by the larvae caused the pile to fall out at spots on the top of the back and on the outer side of the arm. In the companion photograph of the same chair, shown in Figure 26, the mohair covers have been laid back to show that at the top, in pulling the layer of cotton batting, the workman who covered the chair broke off a handful of cotton and failed to remedy his carelessness. On the arm the two layers of cotton batting are improperly overlapped. In each case the vegetable filling, in which the larvae like to nest when not feeding on the cover, was allowed to come in direct contact with the cover itself, thus establishing a paradise for the larvae. (Fig. 14.) Figure 27 in like manner shows how carelessness in construction in six distinct places may have resulted in loss to the purchaser. Sometimes very young larvae of the clothes moth can push their way through a woolen cover that is backed with a layer of cotton batting, but even if they succeed

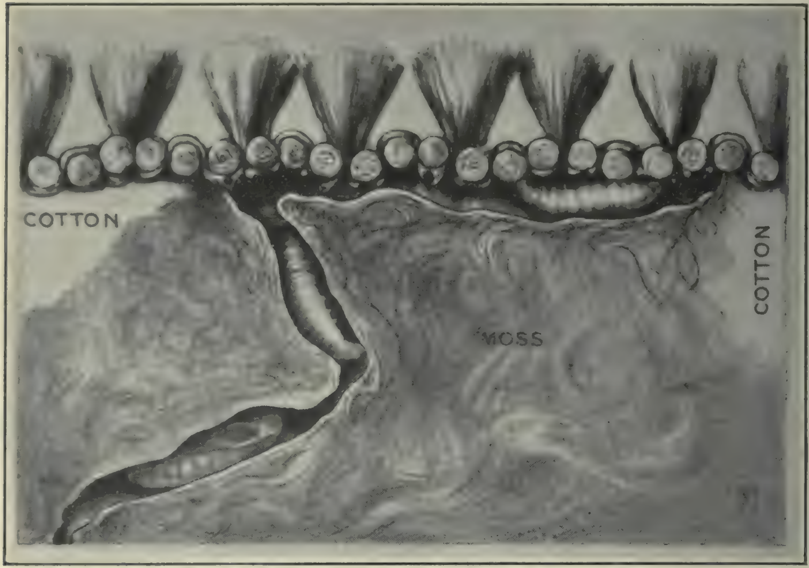

FIGURE 23.—Cross section of a portion of overstuffed furniture covered with mohair. This is a diagrammatic drawing showing that injury through feeding from beneath the cover is confined chiefly to spots where the cotton, shown as white areas at each side beneath the mohair, is broken or carelessly applied over the curled hair or Spanish moss. In this illustration the moss touches the mohair in the central area. Clothes-moth larvae build their silken tubes in the moss and crawl up to the mohair covering when they wish to feed. Notice how the two worms shown have cut the woolen threads of the pile where they pass beneath the foundation warp. The condition shown in Figure 24 results. Enlarged 2 diameters

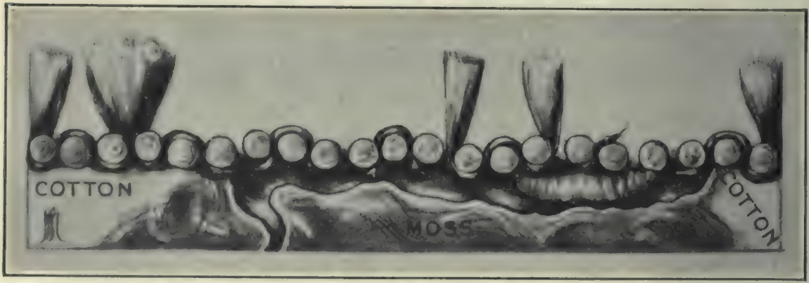

FIGURE 24.—The same covering as shown in Figure 23, after it has been thoroughly brushed or cleaned by vacuum. Notice that the pile has fallen out wherever it has been cut from beneath. It is the development of these bare spots in the furniture covers that affects the aesthetic value of the furniture more than the actual loss of materials eaten. Enlarged 2 diameters

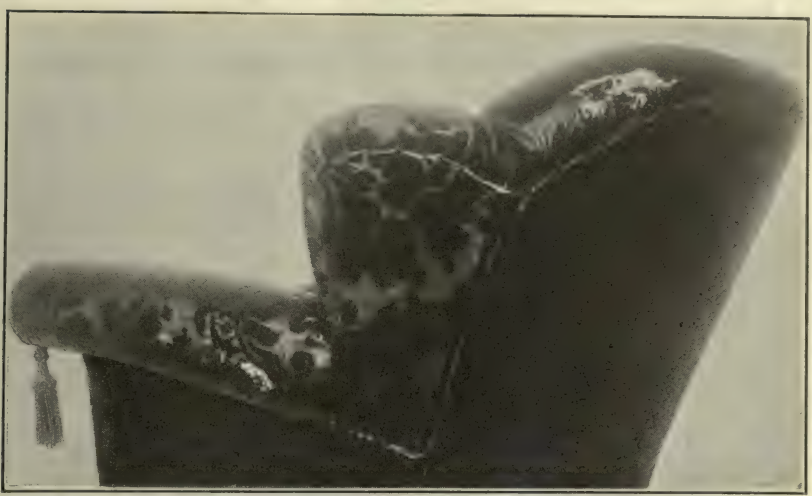

FIGURE 25.—Overstuffed winged chair with bare spots developing at top on back and along outside of arm, where the mohair pile has fallen out. The damage is caused by moths, attacking from beneath the cover. Compare the location of the injury with the places where cotton is lacking in Figure 26

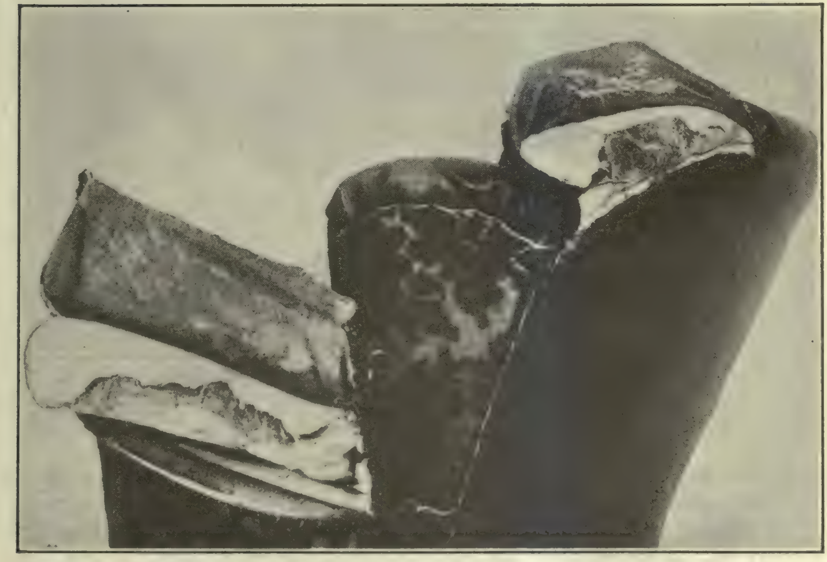

FIGURE 26.—The chair shown in Figure 25, with the covers turned back at points of injury. Notice that the injury to cover is over spots where the cotton is lacking or faultily applied, thus allowing the moss or hair in which moth larvae like to nest to come in contact with the mohair cover

they usually die before reaching maturity. If, however, there is no cotton or other material to stop them, they find conditions ideal for feeding.

THE DEVELOPMENT OF SUCCESSIVE GENERATIONS WITHIN THE FURNITURE

The adult moths are very soft and fragile, and since they can not eat holes themselves, those that mature within the furniture from young worms that have worked their way in find themselves in the darkened open areas at the sides, back, or among the springs, according to where the larva happened to spin its cocoon. Being thus confined is, however, no obstacle to mating and egg laying, and the young larvae upon hatching find an abundance of food in places where they are not molested by housekeeping activities. It thus happens that moths can breed generation after generation within many types of upholstered furniture without being seen from the outside. When infestations become excessive, well-grown white

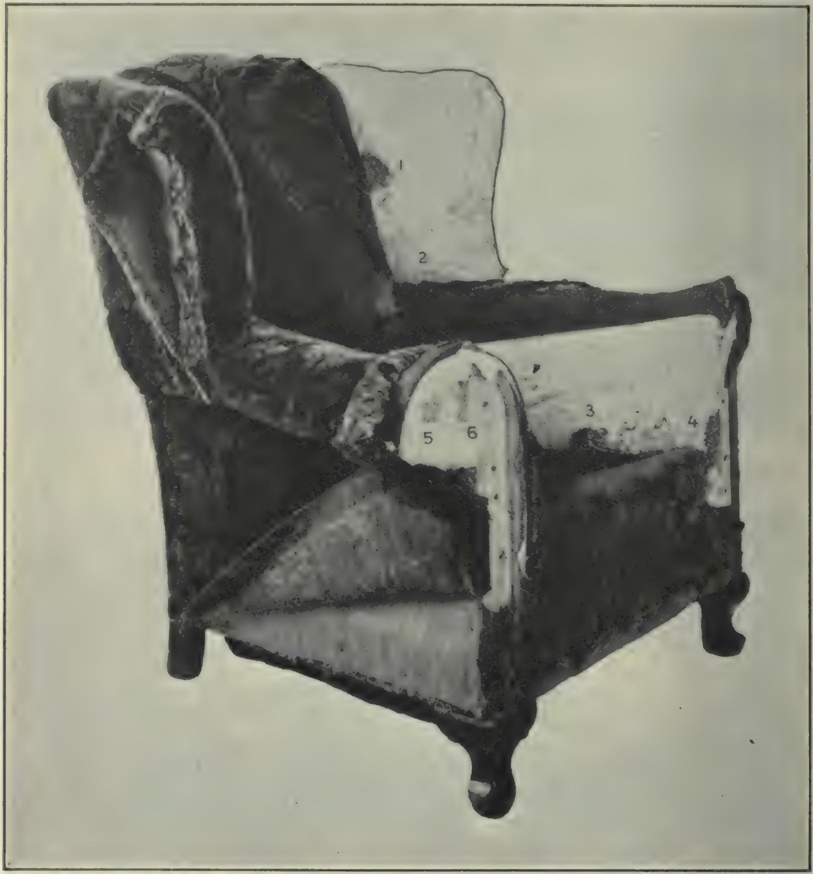

FIGURE 27.—Mohair-covered chair, with cover turned back to show defects in cotton batting (1, 2, 3, 4, 5, and 6) which correspond to external bare spots on the cover, of the same character as those shown in Figure 25. Notice the webs of larvae on inside of mohair at bottom. This was an old and much neglected and abused chair

larvae may become restless, and in seeking new pastures may crawl to the outside and be seen.

FRASS

In handling or opening furniture infested by clothes moths many tiny pellets drop to the floor. They are gritty and hard, and look and, when stepped upon, feel like fine sand. They often fill the furniture stuffings, as is shown in the insert to Figure 14. They are often called eggs of the moth, but in reality are only excrement or frass of the moth larvae, and can in themselves cause no harm. Their color is apt to be similar to that of the food upon which the worms have fed. The eggs of clothes moths are very fragile, soft, and white, and very unlike the larval frass.

CONTROL

Fortunately there are a number of ways to combat moths successfully in upholstered furniture—ways which are not expensive and which permit the enjoyment of any type of cover that satisfies the demand of the owner for beauty, durability, and style. Preventive and remedial measures should be considered.

PREVENTIVE MEASURES

COVERS OF LEATHER, SILK, COTTON, LINEN, OR RAYON

The problem of moths in upholstered furniture can be eliminated for all practical purposes, from the very start, by the use of covers of leather, silk, cotton, linen, or rayon, or fabrics combining these fibers, such as some brocades and tapestries. If cushions filled with feathers are used with these covers there is always the possibility of damage to the feathers themselves (fig. 12), but instances of damage by moths to such cushions are rare.

TREATING WOOLEN COVERS WITH MOTH-PROOFING SOLUTIONS

Leading manufacturers of mohair fabrics are now treating their product with solutions said to render the fabric so treated immune to attack by moths. Although the Department of Agriculture has in its laboratory work found no solution that will permanently and absolutely render any fabric moth proof, the results of this work indicate that the better solutions now available can, if properly applied, impart a resistance that, while not absolute, is of sufficient value to be of practical importance. It is possible when buying furniture with woolen covers to select only such pieces as have covers that have been treated at the factory. Some of these carry guaranties of immunity for several years; and where guaranties are given it is wise to take advantage of them.

UNBROKEN LAYERS OF COTTON BATTING

If the furniture under consideration has a woolen cover backed by a layer of cotton batting between it and the upholstering fibers (such as tow, moss, or hair), the salesman should assure the buyer that in building the furniture the upholsterer has not broken, torn, or improperly applied the cotton layer so as to permit the hair, tow, moss, or other fiber to come in direct contact with the cover. The manufacturer or retailer should be held directly responsible for damage resulting from improperly applied layers of cotton.

CUSHIONS OF SPRINGS AND COTTON BENEATH THE COVERS

Cushions consisting of springs sewed in a linen or cotton cover and surrounded by a layer of cotton batting between the springs and the cover are never infested by moths on the inside, as there is nothing in such a cushion for moths to feed upon. Other cushions built up with a central set of springs covered with linen, surrounded next by a layer of black curled hair, and finally by a linen-covered cushion of feathers or down before the cover is applied, or, instead of the feather cushion, a layer of cotton batting between hair and cover (fig. 28), are practically immune to attack by moths on the inside, provided the hair and feathers were properly sterilized before the cushion was made up.

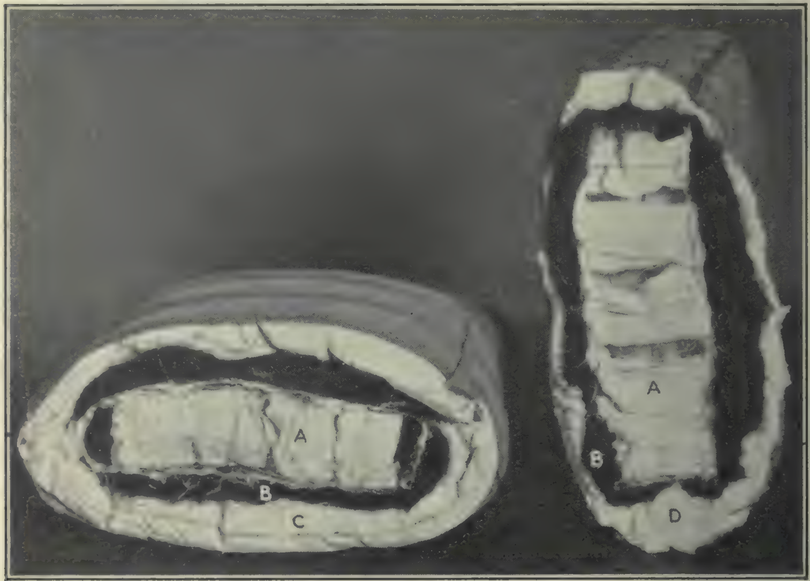

Figure 28.—Cross sections of two types of cushions: A, Springs inclosed with linen or cotton; B, curled hair; C, pad of feathers or down inclosed in linen cover; D, layer of cotton batting.

FUMIGATION BEFORE DELIVERY

A large number of furniture dealers and warehousemen have now provided themselves with fumigating rooms or vaults (figs. 29, 30, 32) in which they can treat returned or secondhand pieces, or pieces intrusted to them for a period of storage. Treatments to kill insects in furniture, either by heat or fumigation, might well be insisted upon as a condition of purchase in case a person wishes to go to the extreme in satisfying himself that no infestation by moths is present

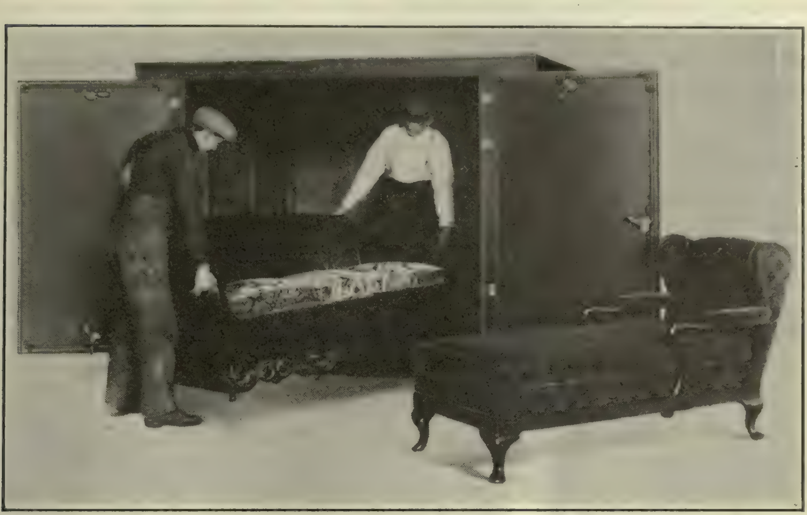

FIGURE 29.—A fumigating room installed by the Bureau of Entomology. This room is 8 by 10 by 6 feet, of steel construction, equipped with an exhaust fan connected with a galvanized-iron pipe through which the fumigant is blown to the roof of the building. The room is installed on the second floor of a 3-story building, and the exhaust pipe runs up the outside of the building. Gas in lethal strength has been held in this room for a number of days. Similar good rooms from the standpoint of tightness and good results can be built of wood, cement, or brick

FIGURE 30.—Furniture being carried into a room equipped for heating furniture to such a degree that all moth life is killed. Several storage firms are enthusiastic over the treatment with heat, and offer this control service to the public

in the furniture at the time of purchase. This service will undoubtedly be given by the manufacturer or retailer at a just price should a request for it be made.

Very effective fumigating rooms can be made of two thicknesses of tongue-and-groove boards with roofing paper between. Care should be taken to provide all rooms with gas-tight doors. Rooms must be so constructed that the gas used can not leak out at the union of walls with ceiling or floor or about the door. Doors must fit tightly. If furniture is to be fumigated during cold weather, it comes into the warehouse well chilled and should be warmed before fumigation begins. For this reason the fumigating room should be equipped with a heating unit of some sort. Never fumigate with an inflammable and explosive gas when the heat is turned on, or until after the heating equipment has had an opportunity to cool.

HOME CONDITIONS

Contrary to the belief of very many persons, clothes moths are present in nearly every dwelling. As shown on page 9, they find food for development and may be present even though no garments, rugs, etc., are found injured by them. In addition to the sources of food listed on page 9, there is the woolen lint that collects in neglected vacuum-cleaner bags or is drawn in and deposited by air currents in the flues of hot-air furnaces. Much furniture is infested by moths that have developed somewhere about the house before flying to the furniture. If a house is thought to be generally infested it is wise to have it fumigated as a whole. This procedure is an excellent way of protecting furniture and all susceptible furnishings.

SLIP COVERS

Much injury by moths can be prevented by the judicious use of slip covers. The unwise use of slip covers favors injury by the process known as surface feeding (p. 14). In seeking a quiet place the adult moth crawls up beneath slip covers and lays her eggs. The larvae hatching from these eggs find sheltered, darkened spots for uninterrupted feeding, and if left unmolested may seriously deface covers in the course of a summer. Slip covers should be removed at varying intervals, according to circumstances, and the pile thoroughly brushed or otherwise cleaned to dislodge or kill moths working in it (p. 17).

REMEDIAL MEASURES

Remedial measures consist in treatments that must be given after purchase to kill moths that may get into the furniture. There are a number of excellent methods for freeing upholstered pieces of all living moths—fumigation, heat, cold, and a combination of fumigation or heat and the application of a dependable moth-proofing solution.

FREQUENT BRUSHING AND TREATING WITH VACUUM

Most important in eliminating the development of surface feeding is frequent brushing and treating with vacuum. If furniture covers are not moth-proofed they should be thoroughly gone over by one of these methods at least once a week to dislodge and crush eggs and kill young larvae of the moth. This careful attention will prevent surface feeding. Surface feeding is always the result of lack of care on the part of the housewife, who alone is responsible for such injury. Surface feeding on the pile is out where it can be seen by careful scrutiny.

FUMIGATION

Fumigation consists in subjecting furniture in inclosures, such as tight rooms or vaults (figs. 29, 31) to gases or vapors that penetrate the upholstering and kill all forms of moth life, including destruction of the eggs. The fumigants most commonly used at the present time (May, 1931) are, in their alphabetical order, carbon-disulphide, chloropicrin, the ethylene dichloride-carbon tetrachloride mixture, ethylene oxide, alone or in combination with carbon dioxide, hydrocyanic-acid gas, naphthalene, and paradichlorobenzene.

Each of this array of available fumigants has some disadvantage or advantage, and which fumigant is to be used will depend upon circumstances. Some, like hydrocyanic-acid gas or chloropicrin, are very toxic to human beings; others, like carbon disulphide, while effective, are explosive and inflammable in the presence of fire in any form. If the service of a professional fumigator is obtained through cooperation with a dependable local storage warehouse for household goods, or with a fumigating company, excellent results can be made to follow the use of any of the above-mentioned fumigants, as they will presumably be handled by persons thoroughly familiar with their characteristics. In general, such firms are very willing to give information regarding any of the fumigants, with directions for application.

But for the average householder who, because of some such reason as isolation, is not able to obtain the services of professional fumigators, it is better to depend upon a treatment that can be applied safely and economically at home, even though it is not the best known method of eliminating moths. For home treatment by the housewife the use of paradichlorobenzene is recommended.

PARADICHLOROBENZENE

Paradichlorobenzene is a white crystalline chemical, similar in general appearance to flake naphthalene. If the crystals are finely divided and applied in any manner, such as scattering by hand, over the furniture covers, down round the cushions, especially where the cushions touch the arms and back of the furniture, and even down into the spaces at the sides and back, they evaporate, forming a gas or vapor that is heavier than air. If the vapor can be confined with the piece of furniture long enough and in sufficient concentration, all stages of the moth will be killed.

To assure this concentration, 2 or 3 pounds of the crystals should be well distributed over the covers of a chair, and the furniture immediately wrapped in several old blankets which overlap one another well and more than touch the floor on all sides. Instead of blankets, large rubberized bags (fig. 31) or large shellacked cartons may be used. If, during warm weather, furniture is allowed to stand several days thus treated and wrapped, practically all moths

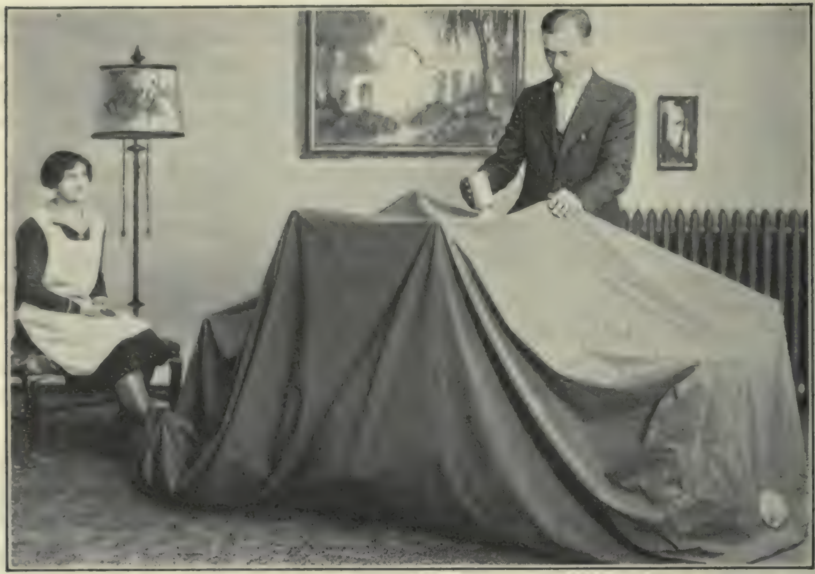

FIGURE 31.—A rubberized bag into which upholstered furniture can be placed after treatment with paradichlorobenzene crystals or with certain fumigants. The man in the picture is attaching a can of carbon tetrachloride to the upper valve of the bag. Such bags, or shellacked corrugated cartons, are best used for treatment with paradichlorobenzene

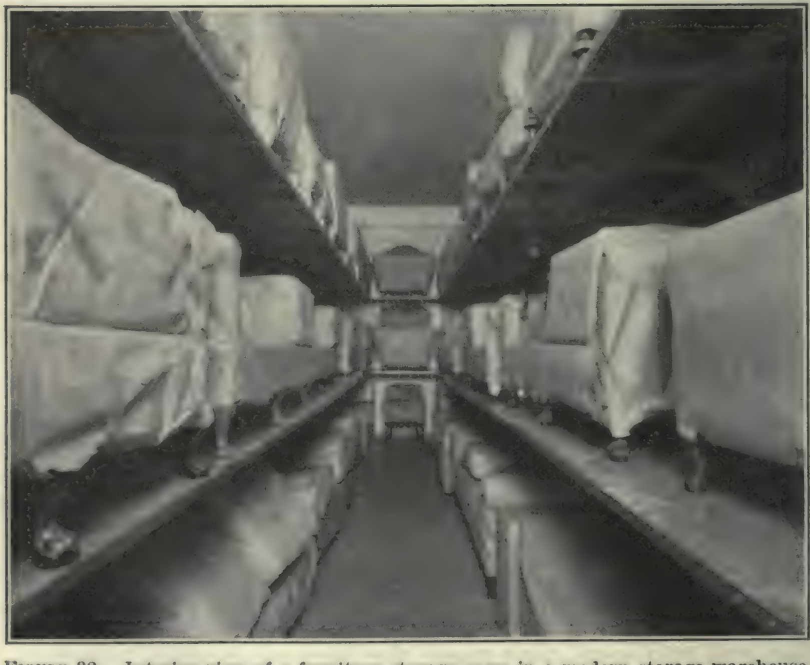

FIGURE 32.—Interior view of a furniture storage room in a modern storage warehouse for household goods. Each piece is wrapped in heavy paper after treatment with paradichlorobenzene or flake naphthalene. Sometimes the crystals are placed beneath the furniture instead of directly on the covers. Do not allow the crystals to stand on the exposed surfaces of the frame

within it will be killed. This is not as good a treatment for the home as fumigation by a professional, but it is safe, easily applied, and reasonably effective if the room temperature is 70° F. or above during the period of treatment. In certain tests made by the writers excellent results were obtained by a 2-day exposure in very warm summer weather.

If a room is to be vacant for several weeks, as during a vacation period, or between seasons at hotels, etc., clothes moths have been very well controlled by wedging all windows and doors, pulling shades, and scattering, over papers spread upon the floor, 8 or 10 pounds of paradichlorobenzene crystals to each room of average size. Although less than a pound of the crystals per 1,000 cubic feet is needed to saturate the atmosphere, there is much leakage from any ordinary house room, and the dosage suggested will provide for continuous evaporation for several weeks. The eyes and nose will smart when a room so treated is first entered. However, the odor of paradichlorobenzene is quickly dissipated, and is recognized only with difficulty after several days of ventilation. Flake naphthalene can be used in the home, but the odor persists longer than that of paradichlorobenzene, and the flakes do not appear to evaporate so rapidly. Only the best grade of paradichlorobenzene crystals should be purchased. They cost in bulk about 20 to 25 cents per pound. Addresses of manufacturers will be furnished by the Bureau of Entomology in case local druggists do not carry a stock. Figure 32 illustrates the excellent manner in which household-goods warehouses protect mohair furniture sent to them for storage. These tight rooms are kept well stocked with paradichlorobenzene or flake naphthalene, and in them no injury occurs.

HEAT

The use of heat as a means of killing moths in upholstered furniture is possible, as a rule, only in warehouses equipped with specially constructed rooms (fig. 30) in which the temperature can be raised. Schlossberg found that in such rooms the thermometers outside the furniture should register between 165° and 170° F. through a 5-hour period, to assure the destruction of moths of all stages. Blistering of the wood finish is apt to occur, but the cost of refinishing is relatively slight.

COLD

Placing furniture on porches or the roofs of apartments during zero (Fahrenheit) weather will kill all moths within a few hours after the zero temperatures reach the individual moths. The unfortunate feature of this otherwise excellent control is that zero weather is seldom available at the right time and place.

COMBINATION OF FUMIGATION AND MOTH-PROOFING SERVICES

The great drawback to any effective fumigation of upholstered furniture is that no fumigant is known that will render the treated piece immune to future infestations. As soon as a fumigated or heat-treated piece is exposed in a house where moths exist (as they do in nearly every house, regardless of the owner's belief) it is subject to reinfestation by eggs deposited on its covers by a flying moth.

To meet the need for a prevention of reinfestation after fumigation, a number of moth-proofing solutions are now available. The most effective of them are the fluoride, cinchona-alkaloid, and rotenone solutions. Solutions containing arsenic in any form are not advocated, the use of arsenic in this manner having been disapproved by the American Medical Association. As already stated (p. 23), the laboratory experiments of the Department of Agriculture have indicated that no solution now available will render fabrics absolutely and permanently immune to the feeding of moths. Yet, when the better solutions are properly applied, under pressure, by spraying machines, they impart a resistance of practical value in this respect. So effective are they that moth-proofing services are now available in all large cities through storage warehouses for household goods, dry-cleaning establishments, or through special agencies. In some instances a guaranty against damage by moths for a term of three to five years is given at the time of treatment.

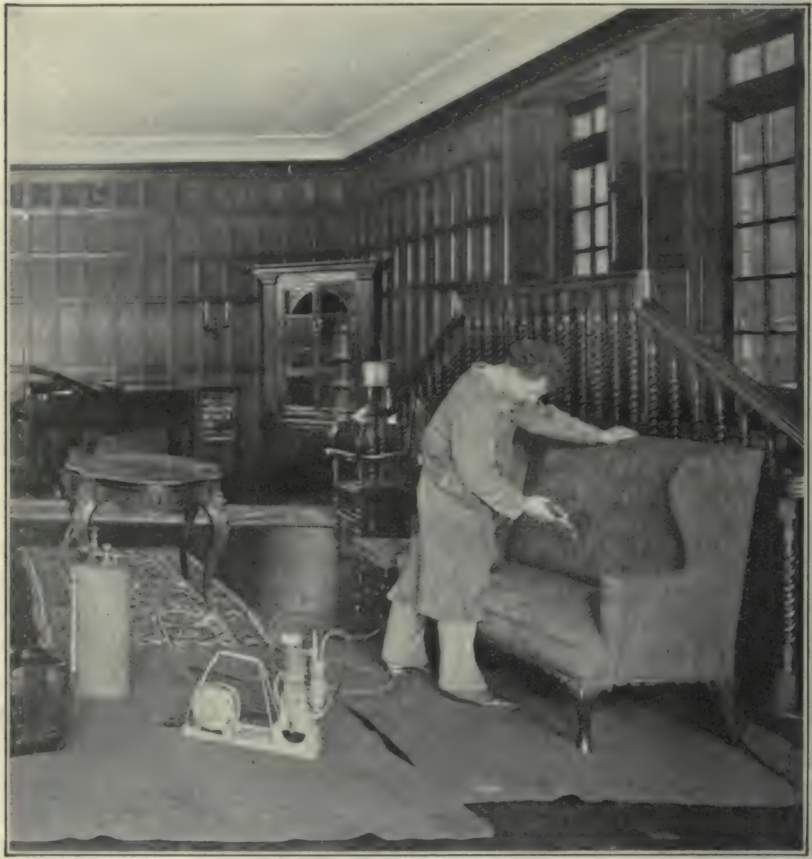

FIGURE 33.—Workman from a storage warehouse for household goods treating furniture with a moth-proofing solution. This method of treatment is increasingly being applied to furniture in all types of homes

In Figure 33 a workman from a firm specializing in demothing and moth-proofing service is shown applying a moth-proofing solution to furniture in a private home. In Figure 34 is shown the method of applying, under air pressure, an aqueous fluoride solution to a couch covered with woolen tapestry.

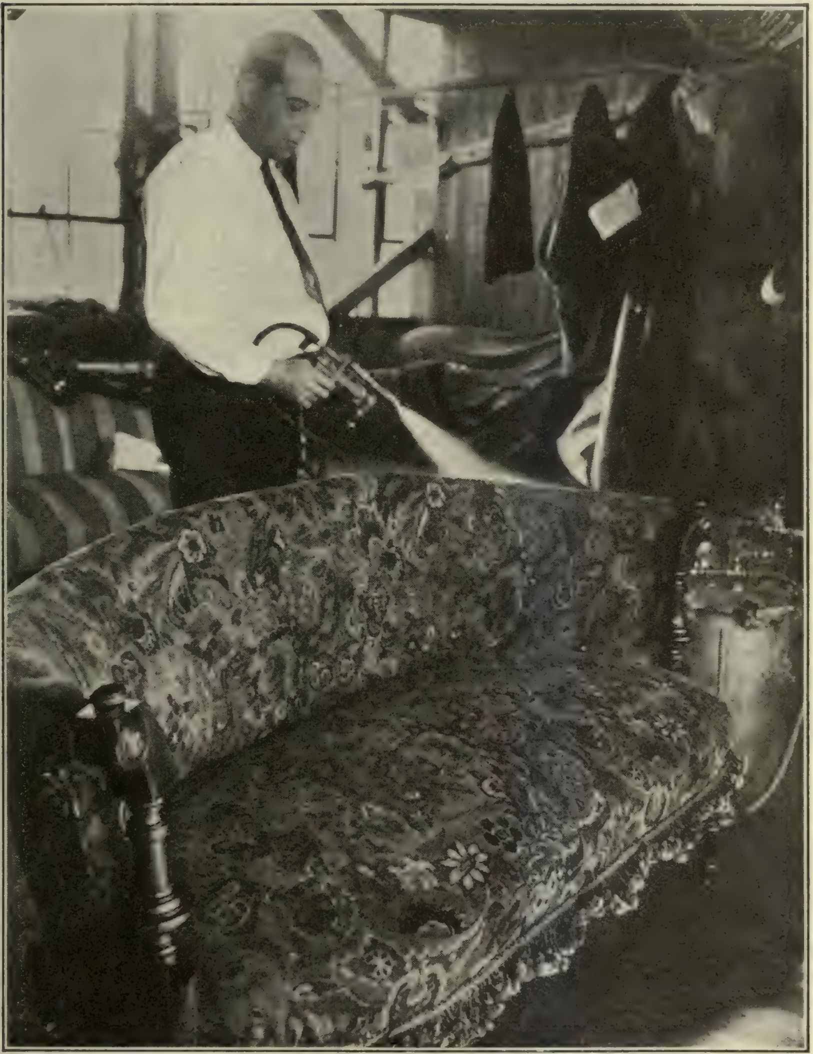

FIGURE 34.—Man applying under air pressure an aqueous fluoride solution to a couch covered with woolen tapestry. The couch was fumigated before the solution was applied

CAUTION

Moth-proofing solutions applied to furniture covers are of value only if the covers are thoroughly saturated. Many persons have had unsatisfactory results from applications made at home by spraying the liquid as a mist from pint or quart bottles by means of a finger-worked sprayer. Even one of the better solutions is ineffective when so applied. If reliance is placed on moth-proofing solutions it is wise to have the solution applied by a power outfit.

CONTACT SPRAYS

There are available on the market a number of sprays consisting largely of light mineral oils, with or without a small percentage of the extract of pyrethrum and variously scented, which deserve consideration in eradicating moth infestation from upholstered furniture. The vapors of fumigants penetrate and kill all stages of the moths which they reach in proper concentrations. Moth-proofing solutions are of value in proportion to the moth resistance they impart to the treated fabric, but these so-called " contact sprays " must actually reach and spread over the bodies of the clothes moths and the egg, worm, and pupa stages if they are to be effective. They are called contact sprays because their effectiveness depends upon their being brought in contact with the insect itself. They are of no practical value if merely sprayed lightly over furniture covers.

Infestation in the pile of mohair and other covers can be killed out very easily by spraying the furniture with an oil spray. Most of the serious infestations in furniture, however, are beneath the covers where they are not so easily reached by the more ordinary methods of spraying employed in the average home. To reach moth worms beneath the covers of furniture and kill them with an oil spray the spray should be applied with considerable force, preferably with the aid of a power sprayer in the hands of a professional. Even when applied in the most thorough manner, oil sprays are not the equal of fumigants, for they can not be made, as commercially applied at present, to penetrate all parts of the furniture. However, examinations of mohair-covered furniture sprayed with oil contact sprays applied with a power outfit showed all moth worms directly beneath the covers killed and only a very few worms still alive in the upholstering material considerably farther in.

It would seem that oil contact sprays can be used periodically for the satisfactory prevention of moth injury to mohair and other susceptible covers and that they can be applied satisfactorily by the owner himself, but better still by firms making a business of treating furniture. These sprays have an odor that should disappear within a few days.

Moth worms in furniture can be killed by saturating the upholstering with kerosene or gasoline which will kill the insects reached. These should be used with care, however, because of the fire hazard, and preferably during warm weather and in an open situation.

Caution.—In using oil sprays follow the directions that come with the spray selected and be sure that you have the assurance of the manufacturer that the spray will not spot the covers. Careless use of oil sprays may result in the spotting of the covers.

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U. S. GOVERNMENT PRINTING OFFICE: 1932

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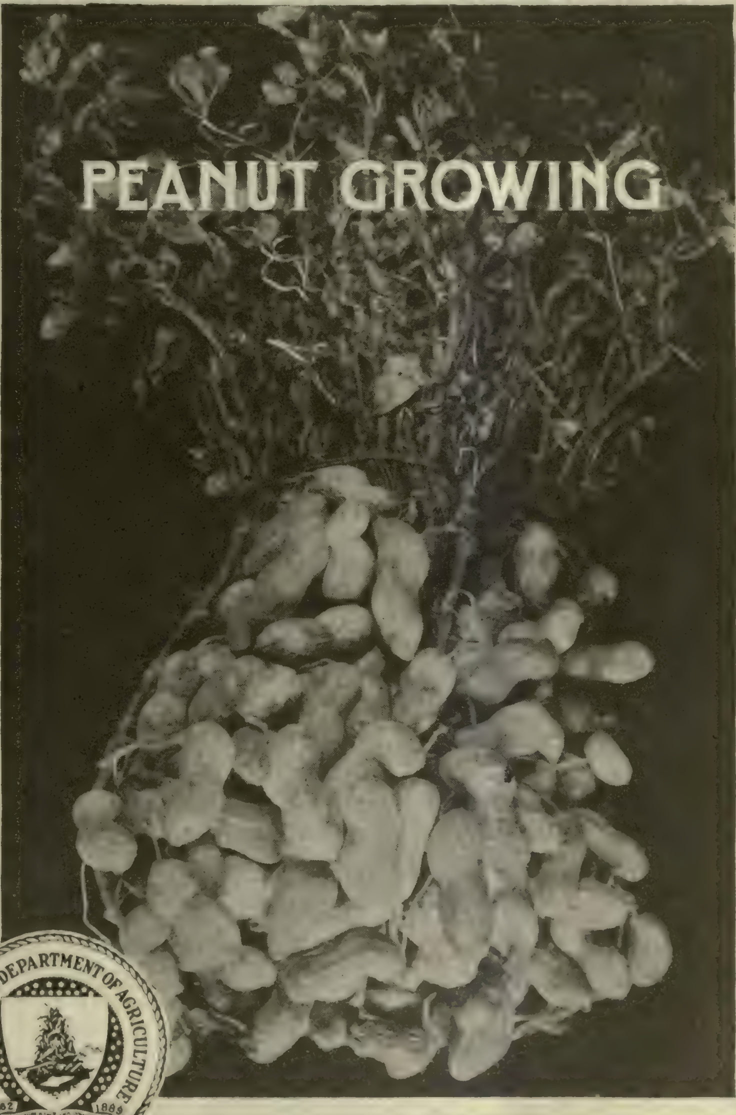
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1656

PEANUT GROWING



PEANUTS are an important farm crop throughout the greater part of the Southeastern States. The peanut is a native of the Tropics and was introduced into North America during the early colonization period, but its use has increased very greatly during recent years.

Peanuts should be grown in a definite rotation, including at least two soil-improvement crops, such as cowpeas, velvetbeans, soybeans, bur clover, crimson clover, vetch, or any crop that will add organic matter to the soil. Peanuts should not be planted on the same land oftener than once in three or four years.

Experimental results show that the kind and quantity of commercial fertilizer that may be profitably used for peanuts depend almost entirely on the fertility and character of the soil. Tests in Virginia have shown that large quantities of nitrogen used on a fairly fertile soil always produce a poor quality of peanuts without materially increasing the yield. On thin, sandy soils and those not in a good state of fertility 300 to 500 pounds per acre of a complete fertilizer may, as a rule, be used to advantage.

Results obtained from the use of lime on peanuts by various investigators indicate that the quality of the peanuts is affected much more than the quantity. Peanuts grown on soils containing the proper amount of lime are usually better filled, the shells are whiter, and they have greater weight per bushel.

Good seed is the foundation of a profitable crop of peanuts. The size of the peanut kernels depends largely on inherent qualities and not upon occasional large seeds.

This bulletin is a revision of and supersedes Farmers' Bulletin 1127, Peanut Growing for Profit.

Washington, D. C. **Issued February, 1931**

PEANUT GROWING

By W. R. Beattie, *Senior Horticulturist*, and J. H. Beattie, *Associate Horticulturist, Office of Horticultural Crops and Diseases, Bureau of Plant Industry*

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PEANUTS are an important money crop in no less than nine of the Southern States. The peanut is a native of the Tropics and was introduced into North America during the early days of colonization but did not become of commercial importance until about 1876. From that time until about the beginning of the twentieth century its importance as a farm crop was relatively small, but since then the production and uses of peanuts have increased enormously.

CONDITIONS NECESSARY FOR PEANUT GROWING

The peanut is a pea rather than a nut and belongs to the same group of plants as do beans and common garden peas, differing only in that it possesses the character of maturing its fruit, or pod, beneath the surface of the soil. The small yellow flowers are borne at the joints where the leaves are attached to the stems, and as soon as pollination takes place the flower fades and the "peg," as it is commonly called, elongates and goes into the soil, where the pod develops. Hence, it is essential that the crop be grown on soil where a loose surface can be maintained.

Peanuts will adapt themselves to a wider range of climate if soil conditions are favorable than almost any other southern crop. The climatic requirements of the peanut are a season of 100 to 140 days without frost, moderate rainfall during the growing period, an abundance of sunshine, and a relatively high temperature. Best results are secured under conditions where the normal annual rainfall is from 42 to 54 inches. Peanuts are frequently grown under irrigation. However, fair yields have been made without irrigation where the annual rainfall is less than 19 inches. On the other hand, good crops have been produced on low bottom lands with 54 to 60 inches of rainfall.

Light sandy loam soil is best adapted to the production of peanuts for the market. Poorly drained or sour soils are not generally desirable. For hog feeding or as forage the crop may be grown on almost any type of soil except the black waxy and extremely heavy clays. Sandy loam soils that will produce good crops of beans and potatoes are considered suitable for growing peanuts.

The territory indicated on the dark portion of the map shown in Figure 1 is, for the most part, adapted to the production of peanuts. Outside of this area their cultivation is more or less uncertain, although in a few localities they may be grown successfully for stock feeding. The soil and climate conditions of southeastern Virginia and northeastern North Carolina seem to be especially adapted to the growing of the Jumbo, Virginia Bunch, and Virginia Runner varieties, which constitute the bulk of the large-podded peanuts appearing on our markets. Throughout the Gulf coast region, Oklahoma, and Arkansas the Spanish variety has proved satisfactory, but peanuts of the runner type are grown extensively in Alabama and Florida.

SELECTION AND PREPARATION OF THE SOIL

In selecting land for peanuts, two things must be considered: (1) The character and adaptability of the land and (2) the character of the crops planted or the rotation practiced during previous years. The peanut crop is subject to injury from crab grass and other weeds; therefore, it should follow some crop that has been kept clean. Cowpeas, velvetbeans, sweetpotatoes, and potatoes are good preparatory crops. Winter oats also are frequently followed by a late-planted crop of peanuts. Cornstalks or cotton stalks interfere greatly with the cultivation and harvesting and should be either removed or plowed under to a depth of at least 8 or 9 inches.

Peanuts should not be planted on the same land oftener than once in three or four years. The rotation should include at least two soil-building crops, one of which is a winter cover crop. Cowpeas, velvetbeans, or soybeans, planted either alone or with corn, are good soil builders. Winter cover crops include bur clover, crimson clover, giant red clover, alfalfa, vetch, rye, barley, purple-top turnips, and English cow-horn turnips.

In a rotation experiment conducted at the Virginia Truck Experiment Station, near Norfolk, the crop rotation consisted of corn with crimson clover as a winter cover crop during the first year, early potatoes followed by cowpeas the second year, and Spanish peanuts the third year, followed by rye as a winter cover crop. Alongside of the three plots handled in rotation is a similar plot on which peanuts are grown continuously. This experiment extended over a period of 10 years, and for the last 3 years the rotation plots yielded approximately three times the quantity of peanuts produced on the continuous plot.

Another rotation which gave good results at the Pee Dee Experiment Station, Florence, S. C., included peanuts the first year with a winter crop of oats and vetch following the peanuts. These were harvested for hay and the land devoted to cowpeas, which were also harvested for hay. A crop of sweetpotatoes the third year completed the rotation. The peanuts and sweetpotatoes were fertilized, but no fertilizer was used on the forage crops. Yields from the rotation area at the end of six years compared favorably with those from adjacent areas, indicating that a rotation of this character is possible.

If considerable rough material is to be turned under, fall or winter plowing should be practiced except on soils that wash badly. Buckshot or other heavy soils on which peanuts are grown for stock feeding are benefited if turned up to the action of frost during the winter months.

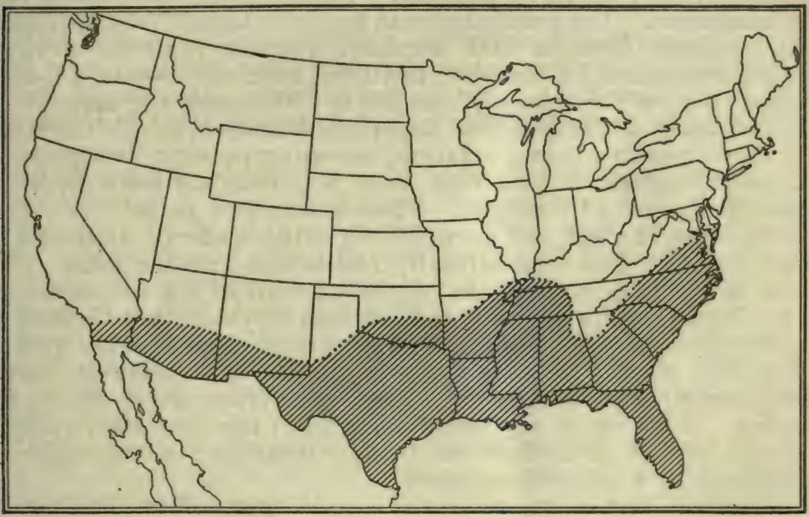

FIGURE 1.—Outline map of the United States, suggesting the possible area adapted to the production of peanuts

Thorough preparation of the land before planting is essential. The Virginia peanut grower, although his land is naturally mellow, plows every inch of space, then harrows and drags it at least three times, or until the soil is in the best possible condition. The subsequent cost of cultivation is thereby greatly reduced. The land should be plowed broadcast, preferably with a 2-horse turning plow, rather than bedded, as is often done for cotton or corn. With good seed and thorough preparation of the soil the Virginia farmer secures a good stand, without which a profitable crop can not be made.

FERTILIZERS

The kind and quantity of commercial fertilizer that may be profitably used for peanuts depends almost entirely on the fertility and character of the soil. Virginia Agricultural Experiment Station Bulletin 229, Experiments with Cotton and Peanuts and Crops Grown in Rotation with Them in Nansemond County, states:

> Our experimental results show that large quantities of nitrogen used on a fairly fertile soil always produce a poor quality of peanuts. At the same time the yield is not materially increased. * * *
>
> In order to fertilize peanuts judiciously it is necessary to study the condition of the particular soil and supply those elements which seem to be lacking. If the soil will produce a fair growth of vines, the use of nitrogen and potash can be eliminated. If the soil is light and sandy and lacking in organic matter a complete fertilizer will pay. A complete fertilizer analyzing 2 per cent nitrogen, 8 per cent phosphoric acid, and 4 per cent potash, with all the nitrogen from an organic source, is recommended for general use on thin, sandy soils. This may be used at rates varying from 300 pounds to 500 pounds to the acre, depending upon the fertility of the soil.
>
> Acid phosphate at rates of application varying from 300 to 500 pounds to the acre to hasten maturity is the only fertilizer recommended for this crop on heavy, fertile soils.

The Alabama Agricultural Experiment Station in its Bulletin 193, Peanuts—Tests of Varieties and Fertilizers, advises the use of phosphoric acid for peanuts on practically all soils and potash under certain conditions. The results indicate but little benefit from nitrogen.

In southern Georgia and northern Florida practical growers strongly recommend a complete fertilizer, such as 3–9–5 or a 2–10–4 mixture, used at the rates of from 250 to 500 pounds per acre.

Experiments at the Pee Dee Experiment Station, South Carolina, with fertilizers in a 3-year rotation, including peanuts, forage crops, and sweetpotatoes, showed that there was comparatively little response to the use of fertilizer. Phosphorous and potash both gave some increase in yield, but nitrogen was without effect. It should be stated that this land was naturally fertile and that the green crops grown in the rotation kept the organic content of the soil at a high level. These results bear out the findings of other investigators to the effect that fertilizers have little influence on peanuts if the ground is naturally good. As a consequence, the use of commercial fertilizers is not so important where soil-building crops are grown in the rotation. However, if any doubt exists as to the need for fertilizer, it should be used in moderation, thereby insuring the crop sufficient plant food for a good development.

Commercial fertilizers are usually applied just before planting the peanuts. However, if applied three or four days in advance they will become better mixed with the soil. The fertilizer is usually applied directly in the row, using a 1-horse distributor. In other cases 1-row or 2-row planters with fertilizer attachments are used in order that the work can be done at one operation. Precautions should always be taken to mix the fertilizer with the soil so that large amounts of it will not come in contact with the seeds.

Peanuts require a fair amount of organic matter in the soil, and this may be supplied either in the form of well-rotted manure or by means of soil-improving crops such as cowpeas, clovers, vetches, or any crop ordinarily used in the locality for improving the soil. Wherever manure is used, either it should be applied with some other crop in the rotation, or, if put on while fitting the land for peanuts, it should be thoroughly mixed with the soil. Because of the limited supply of manure available on the average farm, it can be used, as a rule, to better advantage on other crops than peanuts. Many growers believe that the use of manure causes an excessive development of vine growth and an increased number of "pops" or poorly filled pods.

Peanuts as ordinarily handled do not improve the soil, despite the fact that they have the power of collecting the free nitrogen of the atmosphere and storing it in nodules upon their roots. (Fig. 2.) If, in harvesting, the greater part of the roots are cut off and left in the ground, the drain on soil fertility should be reduced to a minimum. Because of the system of harvesting now followed, however, peanuts do not improve the soil as do the clovers, cowpeas, velvetbeans, soybeans, and alfalfa, the root systems of which are not removed from the ground.

LIME AND GYPSUM

Results obtained from the use of lime on peanuts by various investigators indicate that the quality of the peanuts is affected much more than the quantity. Peanuts grown on soil having sufficient lime are usually better filled, the shells are whiter, and they have a greater weight per bushel.

Work conducted by the Virginia Agricultural Experiment Station, at the branch station at Holland, Va., and reported in its Bulletin 229, indicated no benefit from the use of lime. Decreased yields were even obtained from the use of burned oyster shells at rates of 2 and 4 tons per acre.

In Bulletin 262 of the North Carolina Agricultural Experiment Station, Value of Lime on Norfolk Sandy Loam Soil, additional findings on the use of lime are given. This work was carried on at the Upper Coastal Plain Branch Station in Edgecombe County on a gray sandy to fine sandy loam soil which is representative of much of the coastal plains section of North Carolina. In practically all cases limestone with and without other elements decreased the yield of peanuts. The writers of that bulletin conclude that "peanuts grown in rotation are rarely benefited enough from applications of lime to justify its use on this type of soil."

The Alabama Agricultural Experiment Station reports, in Bulletin 193, the results of several tests with lime on peanuts and concludes "that slaked lime at the rate of 600 pounds per acre made a profitable increase when applied to sandy soil."

A lime application test was carried on at the Pee Dee Experiment Station during 1917, 1918, and 1919. The soil, Orangeburg sandy loam, had not been limed for 10 years. The results of this test are shown in Table 1.

TABLE 1.—*Effect of application of hydrated lime to Spanish peanuts at the Pee Dee Experiment Station, Florence, S. C., in 1917, 1918, and 1919*

[Plots one-tenth of an acre. The entire area received a uniform broadcast application of 500 pounds per acre of 2-8-3 fertilizer while the ground was being prepared]

Treatment	Lime per acre (pounds)	Acre yield in 30-pound bushels in—		
		1917	1918	1919
Lime harrowed in before planting	None.	20.1	21.6	35.5
	500	24.0	20.8	37.8
	1,000	21.0	22.0	39.0
	1,500	20.5	23.3	38.7
	2,000	21.0	22.1	40.3
Lime applied as top-dressing 8 weeks after planting	None.	32.1	30.8	33.5
	250	19.1	29.3	35.5
	500	13.8	27.1	33.8
	1,000	18.3	28.6	33.5
	2,000	21.8	------	34.6

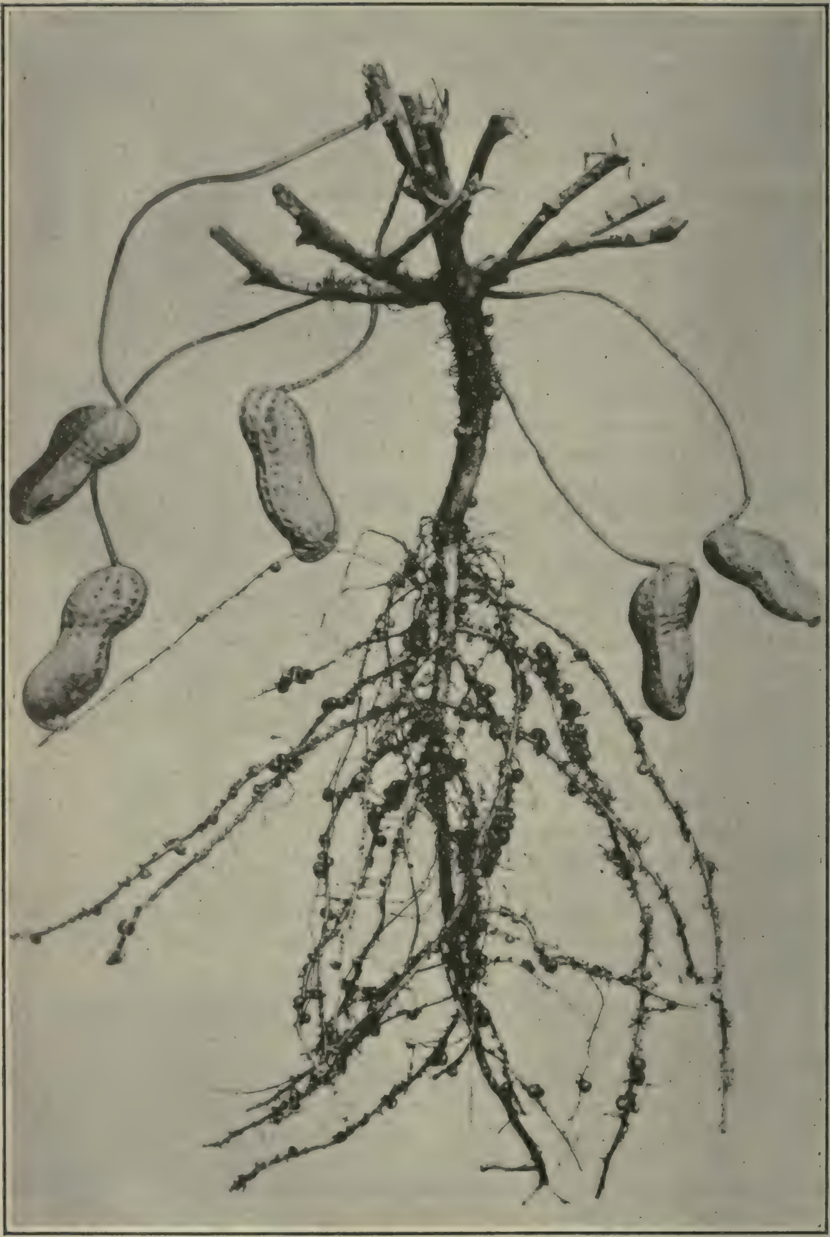

FIGURE 2.—Roots of a peanut plant, showing nodules formed by the bacteria which collect nitrogen

The nature of this test is such that definite conclusions can not be drawn, but the results indicate that lime had no marked effect on the yield. A slight depression of yield as the result of top-dressing with lime is indicated. Later work, still in progress, shows similar results.

These tests indicate that additional lime is not always needed by soils devoted to peanuts, but it would be a great mistake for any grower to conclude offhand that he should not use lime. It should also be borne in mind that the lime requirements of adjoining fields may differ and that the only safe method is to test the soil acidity, or, if it is thought that lime is needed, to make a moderate application of 500 to 600 pounds per acre. On soils requiring lime its application exerts such a marked effect on the quality and possibly the yield of the crop that one can not afford to take the chance of not using it.

Gypsum, like lime, is sometimes beneficial to peanuts, and is usually used at about the same rate as lime. Numerous experiment station tests show response or lack of response, as the case may be, from the applications of gypsum, depending on the needs of the soil. The only safe thing to do is to determine the actual need of the soil for gypsum before applying.

PEANUT SEED AND ITS CARE

SELECTION OF SEED

The size of the peanut kernels depends largely on inherent qualities and not upon occasional large seeds. It is of little use, therefore, to employ large-size seed screened out of miscellaneous lots without consideration of their hereditary lines. Many peanut growers have practiced seed improvement for years and have developed strains that are above the average in size and yielding qualities. Much good can be accomplished by locating these special stocks, whether in the hands of growers or of dealers, and using them for planting. Plant breeders are making renewed efforts to produce strains and varieties of peanuts that will yield a higher percentage of extra large kernels. Shellers and cleaners who have in their warehouses desirable seed material of strains that shell a high percentage of fancy kernels can do much to help the industry by making this material available for seed purposes. Growers of Virginia-type peanuts will find it to their advantage to substitute the large-type seed for the miscellaneous small stock which they would otherwise plant, as the substitution would undoubtedly result in a higher proportion of large kernels.

The corn and wheat crops of the country have been increased many millions of bushels through seed improvement, and the same opportunity exists with peanuts. The proper method of producing seed is to grow a special seed patch, the seed for which has been selected from vigorous, high-producing plants the previous year.

Peanuts intended for seed, after becoming fully mature, should be dug carefully during bright weather and placed in small stacks around poles as described under "Curing" (p. 16). After a curing period of at least four to six weeks the seed peanuts should be picked from the vines and stored. Under the most favorable curing conditions peanuts may be ready to pick in three weeks after digging.

STORAGE OF SEED

Special care should be taken to protect peanut seed from damage by insects, mice, rats, squirrels, or other pests, and from unfavorable storage conditions. On the farm a cool, dry, well-ventilated place, such as the loft of a granary or corncrib, is well suited to peanut seed storage. Small quantities, up to a few bushels, may be stored in sacks hung from overhead supports or otherwise protected from mice, rats, and squirrels, or dry seed may be stored in metal cans provided with screen-covered openings for ventilation. A good storage for larger quantities of peanut seed may be provided by building a suitable-sized inclosure or room in a granary or corncrib, covering the floor, sides, and ceiling with ¼-inch wire mesh. A room of this kind will soon pay for itself in the seed saved. It may be sufficiently large to hold any portion of the crop, thereby making it possible to hold peanuts on the farm as long as may be desired without loss from animals.

Work carried on during the period from 1921 to 1926 at the Pee Dee Experiment Station, Florence, S. C., and in the cold-storage plant at Arlington Experiment Farm, Rosslyn, Va., shows that shelled or unshelled peanut seed may be kept in cold storage for several months without appreciable effect on its vitality. A summary of this work is given in Table 2. These findings are of importance because peanuts held in cold storage may be offered for use as seed.

TABLE 2.—*Germination and yield of shelled and unshelled peanut seed kept in cold storage*[1] *(32° and 40° F.) and at natural warehouse temperature, about 70° F., 1921 to 1926*

Variety	Temperature	Germination		Yield per ~~acre~~ plot (1/100	
		Shelled	Unshelled	Shelled	Unshelled
	° *F.*	*Per cent*	*Per cent*	*Pounds*	*Pounds*
Spanish	32	74.84	77.96	15.63	15.75
	40	71.14	75.94	12.63	16.00
	70	76.79	75.87	17.50	15.25
Improved Spanish	32	69.28	71.96	15.50	18.75
	40	65.39	71.09	15.17	16.00
	70	67.67	71.58	14.92	16.92
Virginia Bunch	32	46.08	68.73	8.08	13.75
	40	47.48	66.71	11.00	13.58
	70	49.58	72.11	7.75	17.17
Virginia Runner	32	56.52	73.67	8.75	14.25
	40	52.82	68.60	8.83	12.42
	70	54.57	69.28	10.58	12.75

[1] Cold-storage plant at the Arlington Experiment Farm.

AGE OF SEED

Tests made at the Pee Dee Experiment Station with peanut seed of different ages show that it may be kept for a period of four to five years without serious loss in germinating qualities or appreciable reduction in the size of the crop. Seed grown in the years 1921 to 1926 was planted every year from 1922 to 1927, inclusive. While the seed of both the Valencia and Improved Spanish varieties grown in 1921 and 1922 showed a reduction in germination in 1926 and 1927, the fact that it had been kept for four years without serious deterioration is sufficient for all practical purposes. It would be distinctly advantageous, however, to carry especially good peanut seed stocks over a season or two to guard against failure to secure good new seed. Peanut seed kept over must be stored in a cool moderately dry, well-ventilated place and carefully fumigated twice each season with carbon disulphide to destroy insects. Seed stored from season to season should be unshelled.

PREPARATION FOR PLANTING

During the winter months when there is spare time the seed peanuts should be prepared for planting. The dirt, trash, and light pods should be removed. If a large quantity of seed is to be handled it may be run through the picker under a heavy fan blast. A fanning mill may also be used to separate the heavy, well-filled pods from the dirt and trash. In many cases it is possible to secure seed from commercial peanut cleaners who are willing to set aside high-producing lots for seed purposes. These concerns have equipment for cleaning peanuts at very low cost. After cleaning, the peanuts may be stored unshelled until planting time or they may be shelled. Experimental work at the Pee Dee Experiment Station has shown that peanut seed may be shelled several months before planting without deterioration in quality. The results of this work are summarized in Table 3. Peanut seed shelled as early as December gave practically the same germination and yield as that shelled just prior to planting.

TABLE 3.—*Average germination (per cent) and yield (pounds per acre) in 1922, 1923, and 1924 of seven varieties of peanuts from seed shelled on different dates*

Variety	December shelling		January shelling		February shelling		March shelling		April shelling		May shelling	
	Germination [1]	Yield [2]	Germination [1]	Yield [2]	Germination	Yield [1]	Germination	Yield [1]	Germination	Yield [1]	Germination	Yield [1]
Jumbo	87.07	855	82.91	990	78.26	956.2	81.75	900.0	77.41	1,642.5	78.38	1,046.2
Virginia Bunch	88.89	855	90.97	540	87.07	1,125.0	72.24	1,001.2	86.62	1,530.0	78.90	1,260.0
Virginia Runner	94.16	585	92.63	855	85.66	1,372.5	75.02	1,260.0	85.22	1,395.0	85.57	1,075.0
African	93.05	675	91.67	855	86.21	1,035.0	77.76	922.5	78.67	978.5	83.33	1,237.5
Valencia	92.08	360	93.19	495	88.71	776.2	76.15	630.0	75.32	652.5	87.09	810.0
Spanish	93.16	900	95.55	900	91.96	877.5	86.62	911.2	87.26	900.0	92.62	843.5
Improved Spanish	90.41	1,125	91.24	1,125	92.10	1,327.5	78.58	1,023.5	81.23	1,057.5	85.37	1,023.5

[1] 2 years only. [2] 1 year only.

The utmost care should be observed to avoid injury to the seed when shelling. Breaking of the inner or red skins of the kernels will seriously affect germination. This seems to be especially true when seed is shelled several months before planting. Irrespective of the time of shelling, it is best to shell either by hand or by some type of machine that will not damage the kernels. Peanut shellers are available which will do the work without much damage to the seed, but it is always necessary to hand pick the seed after shelling by machine.[1]

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[1] Complete information on this work is given in U. S. Department of Agriculture Bulletin 1478, Effect of Planting Distances and Time of Shelling Seed on Peanut Yields.

PLANTING

TIME OF PLANTING

Throughout the greater part of the commercial peanut area the planting of the main crop is done between April 10 and May 10, but in no case should the seed be planted until the soil is reasonably warm. The large varieties require a longer period for their development than do those of the Spanish type. Best results are secured from early planting, but in the Gulf coast region Spanish peanuts may be planted as late as July 1 and a fairly good yield obtained. When large acreages are grown, plantings should extend over a period of at least three or four weeks, so that the entire crop will not be ready for harvesting at one time.

PREPARATION OF LAND FOR PLANTING

If the land has been well fitted and leveled, the rows at planting time may be laid off with a 1-horse marker. The fertilizer is then distributed, as described on page 4, and the peanut planter run along the same marks. A planting gang, consisting of a team attached to the harrow, a 1-horse marker, two fertilizer drills, and two peanut planters will plant 10 to 12 acres a day. On a small scale two men with a double team can work to advantage. First, a section of the field is dragged or harrowed; the team is then split, one horse being used to mark the rows and sow the fertilizer, while the other is employed to draw the peanut planter. From 4 to 5 acres a day may be planted in this manner.

PLANTING DISTANCES AND QUANTITY OF SEED

Planting distances depend upon the kind of tools used, the fertility of the soil, and the variety grown. Such varieties as the Spanish, Improved Spanish, Valencia, and Tennessee White, which have medium-sized upright plants, may be planted much closer than Virginia Runner and African, which have large spreading plants. Spanish and similar sorts are often planted in rows 24 inches apart, whereas the larger sorts are sometimes planted in 42-inch rows. Thirty-inch rows for small-top kinds and 36-inch rows for large-top kinds are usually satisfactory. Experiments at the Pee Dee Experiment Station show that on the light sandy loam soils of that region the highest yields were secured where the seeds of both the Spanish and Virginia Bunch varieties were dropped very closely in the row, the best yields being obtained at a distance of 3 inches with the rows 30 inches apart. Practical growers in the southern Georgia peanut area recommend 24-inch rows with 4-inch spacing of shelled Spanish seed. Whether these distances would hold good on the rich river-bottom lands in certain parts of the South is a question, but there can be no doubt that under most conditions a better stand and a higher yield will be secured by closer planting.

The use of shelled seed makes it possible to plant more uniformly, but shelled seed should not be planted until soil conditions are favorable, as otherwise it might rot. The tendency, however, is more and more to the use of shelled seed. Unshelled seed may be soaked overnight to hasten germination. Shelled seed, however, should never be soaked, as such treatment injures the skins and interferes with germination.

A good grade of Virginia-type peanuts will count about 1,000 or even as low as 500 seeds to the pound and Spanish and others of the small types about 1,500 to 1,000 seeds, usually about 1,250 to the pound. By counting the number of rows per acre and by knowing the spacing of the peanuts in the row it is an easy matter to determine the theoretical quantity of seed needed. Plenty of extra seed should always be provided, not only for the original planting but for replanting in case of failure to secure a stand. The number of pounds of seed given in Table 4 varies according to size of seed between the limits stated. Allowance should be made for seed larger or smaller than the sizes given and to provide a surplus for replanting.

Well-cleaned, unshelled peanuts of a good grade are about 70 per cent kernels, 4 to 5 per cent of which will be small. If planting unshelled seed, therefore, provision should be made for at least one-third more seed by weight.

TABLE 4.—*Approximate quantity of shelled peanut seed needed to plant 1 acre*

Variety	Spacing of seeds in row	Quantity of seeds required when planted in rows of the width indicated		
		24 inches	30 inches	36 inches
	Inches	*Pounds*	*Pounds*	*Pounds*
Spanish and other small sorts with 1,500 to 1,000 seeds to a pound	3	55–85	46–69	37–56
	4	43–65	35–52	28–42
	6	29–43	23–34	15–28
	8	22–33	17–26	14–21
Virginia and other large sorts with 1,000 to 500 seeds to a pound	4	65–130	52–104	42–84
	6	43–86	35–70	28–56
	8	33–66	26–52	21–42
	10	25–50	20–40	16–32

HAND AND MACHINE PLANTING

When planting seed by hand, a small furrow is opened with a single-shovel plow, the seed being dropped and covered with a 1-horse cultivator or with a hand hoe. A notched board attached to the back of the cultivator will form a slight ridge of soil directly over the row.

Peanut seed should be covered to a depth of 1½ to 2 inches on light sandy soils and 1 to 1½ inches on the heavier soils. If the soil contains plenty of moisture, the depth should be less than if moderately dry. Slight firming of the soil over the seed is desirable, and the modern planting machines are fitted with a concave wheel that follows the covering blades and slightly rolls or firms the soil.

Much depends upon the care taken by the operator of the planting machine, to see that it is dropping and covering properly. Some of the machines on the market are fitted with agitators, which keep the peanuts from packing together in the hopper. Plenty of seed should be kept in the machine, and any remaining stems or trash should be removed frequently in order to prevent clogging. A peanut planter is shown in Figure 3.

PROTECTION FROM BIRDS AND RODENTS AFTER PLANTING

In sections where crows, pigeons, salamanders, squirrels, or other pests destroy the peanut seed after planting, it should first be spread upon the floor or on a wagon sheet, sprinkled with a mixture of equal parts of pine tar and kerosene, and stirred to distribute the mixture uniformly. It is neither necessary nor desirable that the material cover the entire pod or kernel, as a little will be effective. This treatment may be used for both shelled and unshelled seed, but great care should be exercised to avoid injury to shelled seed while handling.

CULTIVATION

Cultivation of the peanut crop should begin as soon as the rows can be followed and should continue until the vines occupy the greater portion of the ground. Frequent shallow cultivation, similar to that given beans and peas, is the keynote of success in the production of a peanut crop. As soon as the soil is reasonably dry after heavy rains the surface should be stirred, and during dry weather a soil or dust mulch will help to conserve moisture. In some sections of Virginia and North Carolina, on the sandy loam soils that are free from trash, the peanuts are harrowed carefully about a week after they are up, using a light spike-tooth harrow with the teeth set sloping back. At least one hand hoeing will be necessary, and the best time to do it is usually about the time the plants begin to spread, or following the third cultivation. About five cultivations are required; however, the number will depend entirely upon weather conditions.

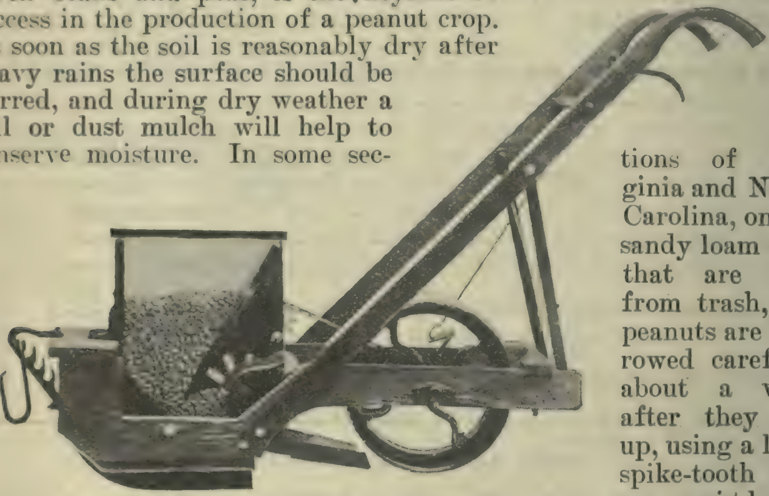
FIGURE 3.—A 1-horse peanut planter

IMPLEMENTS FOR CULTIVATION

In most sections of the South sweeps and 5-tooth cultivators are already on the farms. Of the two the 5-tooth cultivator is preferable, especially if provided with two or three sizes of shovels. The first one or two cultivations should be with the 1¼-inch or narrow shovels, and subsequent workings with the 2½ or 3 inch shovels or points. (Fig. 4.) By working the soil toward the rows during cultivation a broad, flat bed of earth will be formed, leaving a water furrow between the rows.

On light sandy soils, such as are found in many sections of the peanut territory, the greater part of the work of cultivation can be done by means of a 1-horse weeder of the special type shown in Figure 5. This tool is light and can be dragged diagonally across the rows, first in one direction and then in the other, without serious injury to the plants. At the station at Florence, S. C., it has been found that practically no hand hoeing is necessary where the crop is worked about twice a week with this type of tool until the "pegs" begin to form. After the pegs begin to take hold of the soil a riding cultivator may be used between the rows. A small tooth should be placed next to the row and so adjusted that it will not go more than 2 inches into the soil. Next to this there should be a large tooth and a sweep in the center of the row. The vines must not under any circumstances be disturbed after they begin to "peg down," and only the middles should be cultivated after the pods begin to form. (Fig. 6.)

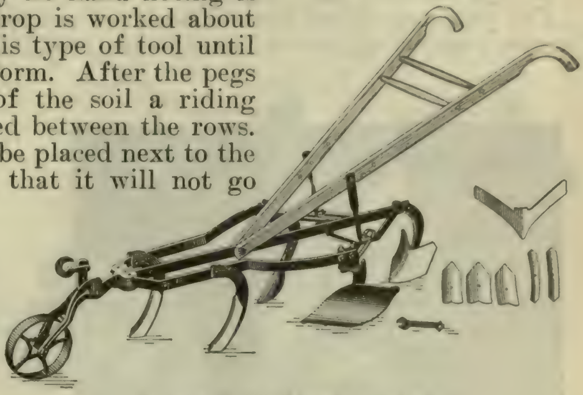
FIGURE 4.—A 1-horse cultivator

After the pegs or pods begin to form they should not be disturbed, but a narrow cultivator or sweep should be used to keep the middles clean and work a little loose soil under the sides of the plants, thus providing a bed of fine earth in which later pods may form.

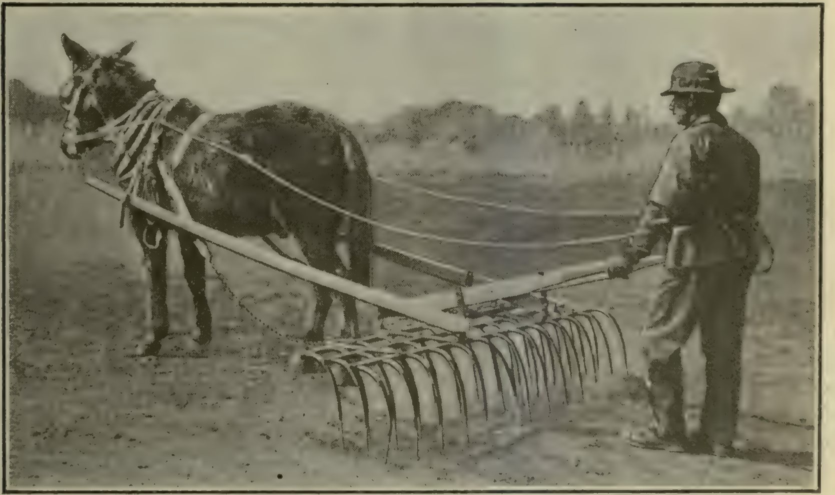
FIGURE 5.—Type of weeder often used for the first cultivation of peanuts

SPECIAL CULTURAL PRACTICES

Shoveling soil upon the center of the peanut plants injures the quality of the hay, and it is doubtful whether a greater number of pods are formed. Running a light roller over the plants after the final cultivation to flatten the stems upon the ground and enable the little pegs to reach the soil may be desirable in the case of the spreading varieties, but it is a questionable practice with the Spanish or any of the erect-growing types.

The primary object should be to so cultivate the crop that the largest possible number of perfect pods will set and mature at the same time, yielding a uniform product.

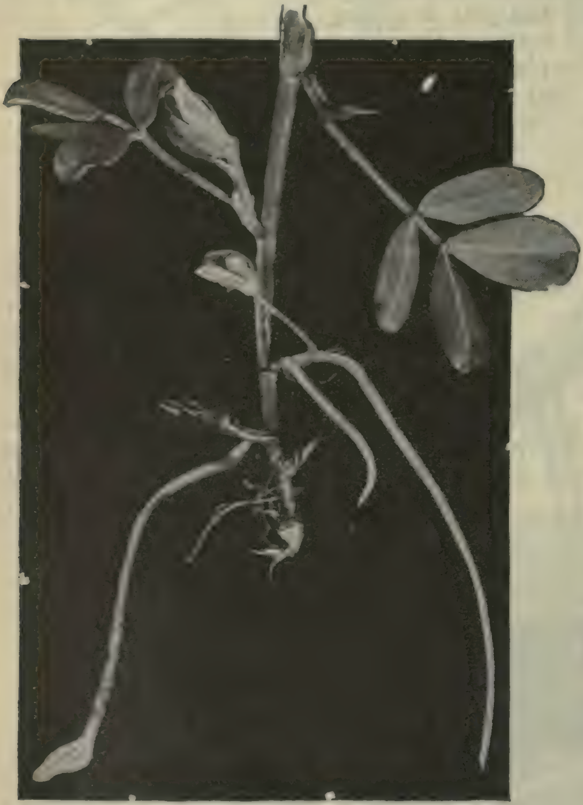

FIGURE 6.—Peanut flower and the pegs that form pods

ENEMIES OF THE PEANUT

The peanut in the United States has been very free from injury during growth by insects and diseases. Several serious diseases exist in foreign countries, and there is grave danger that these may gain a foothold here. Appreciable but undetermined losses to the crop are being caused by leaf spot (*Cercospora personata*) and root rot (*Sclerotium rolfsii*). For controlling or reducing the injury caused by root rot, which often destroys as much as 10 to 15 per cent of the pods, crop rotation is recommended. A rotation including corn, cowpeas, rye, and clover (but not cotton, sweetpotatoes, potatoes, tomatoes, or cucumbers) should be advantageous and should assist in reducing losses from root rot. No known measures exist for the control of leaf spot.

HARVESTING AND CURING

TIME OF HARVESTING

Peanuts should be harvested before the vines are killed by frost. When to harvest the crop may be determined in two ways: (1) By a slight yellowing of the foliage, and (2) by an examination of the pods. If the peas are full grown and the inside of the shells has begun to color and show darkened veins, it can be assumed that they are ready for harvesting. The tendency of many farmers has been to dig too early and before most of the peanuts have fully developed. On the other hand, if harvesting is deferred too long the peanuts shed their leaves, and in the case of the Spanish variety many kernels will be lost by sprouting, especially if a rainy period should occur.

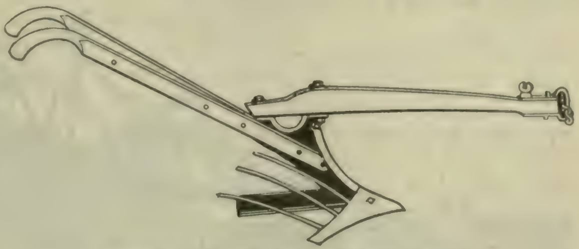

FIGURE 7.—Plow type of peanut digger

METHODS OF DIGGING

Peanuts should be loosened from the soil by means of a sharp implement that will cut off the greater portion of the root system on which the nitrogen nodules are borne. A number of diggers of the plow type that do this in a fair manner are on the market; there are also special peanut points to be attached to an ordinary turning plow from which the moldboard has been removed. (Fig. 7.) A very simple and effective type of peanut digger consists of a sharpened, curved steel bar, which is attached to a Georgia plowstock, as shown in Figure 8.

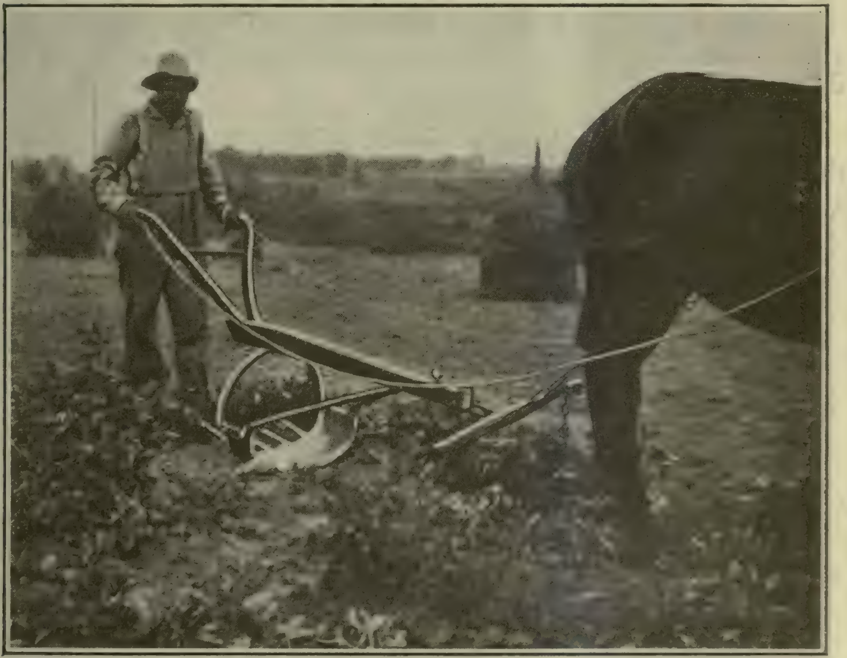

FIGURE 8.—A simple and effective peanut digger made by a local blacksmith

Regular machine potato diggers with elevators (fig. 9) have been found very satisfactory where the soil is reasonably dry and the crop is free from grass. These machines not only lift the peanuts from the ground but also shake off the soil, as shown in Figure 10. By regulating the depth of the point, the roots can be cut off just deep enough to avoid loss of the pods, leaving most of the nitrogen-bearing nodules in the soil.

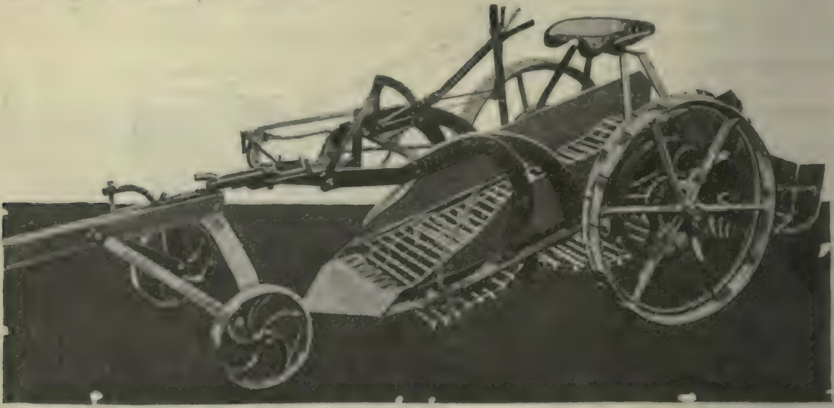

FIGURE 9.—Potato digger used for harvesting peanuts

Digging should not begin in the morning until the vines are dry, and no more should be dug than can be placed in stacks during the day.

CURING

After the peanut vines are loosened and the soil shaken from them they are allowed to lie either spread upon the ground or in small bunches until the leaves are slightly wilted, but not until they become curled or brittle. If the weather is suitable for curing the crop, stacking may begin within an hour or two after digging.

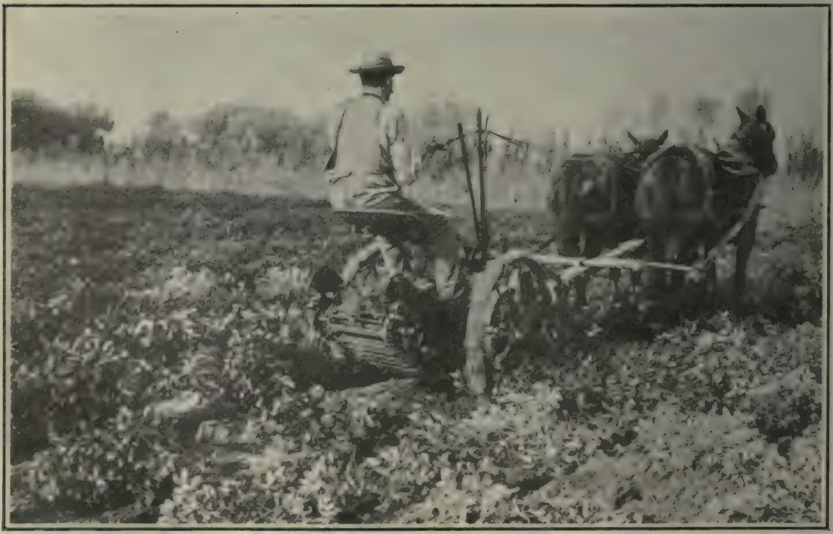

FIGURE 10.—Potato digger used for digging peanuts

There is but one right way of curing peanuts, and that is by putting them in small stacks around poles to which two crosspieces have been nailed a few inches above the ground. Curing in windrows may succeed about one year out of five in sections having little rainfall at harvesting time, but the farmer who uses this method is always taking a great risk of losing his crop.

Small poles or split stakes 3 to 4 inches in diameter at the base, cut 7 feet in length and sharpened at both ends, are the best type of stake around which to stack peanuts. The crosspieces should be 14 to 18 inches long and may consist of edging strips from the sawmill or short pieces of split timber similar to stove wood. From 15 to 30 stacking poles will be required for an acre, and both poles and crosspieces should be ready for use well in advance of harvesting time. Two crosspieces only are required for each pole, and these are nailed at right angles, one directly above the other, as shown in Figure 11.

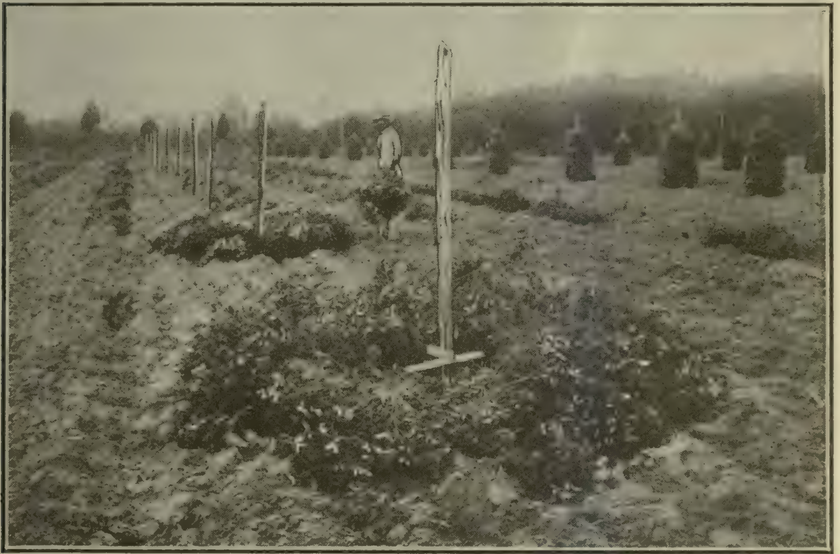

FIGURE 11.—Poles around which stacks of peanuts are to be built

Then 12 to 14 rows of peanuts are placed in a stack row. After a sufficient number of rows are dug the stakes are distributed and set by making holes with a post-hole digger, crowbar, or an old wagon axle, inserting the stakes, and tamping the soil firmly around them so that they will not blow over with the weight of the stack upon them. The crosspieces are then nailed on at right angles to each other 8 to 12 inches from the ground.

For assembling the peanut vines around the stacking poles a fork having six or eight tines is the best implement. As the vines are brought together they are laid in a circle on the ground, with the roots toward the pole at a convenient distance from the pole, so that the person doing the stacking can work comfortably. In starting to build the stack a few vines are hung over each of the crosspieces, thus forming a foundation. The stack is built by piling the vines around

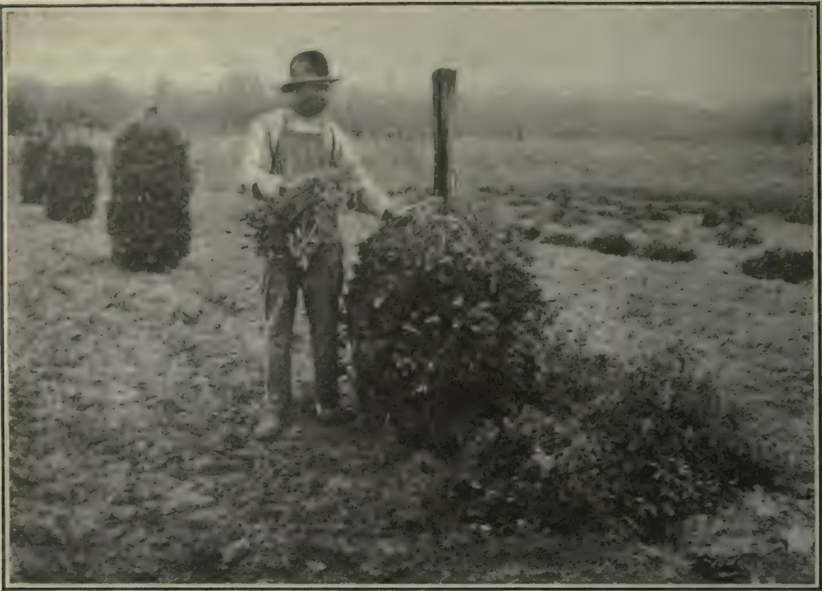

FIGURE 12.—Partly completed stack of peanuts, showing the method of placing the vines in stacking. Completed stacks are shown in the background

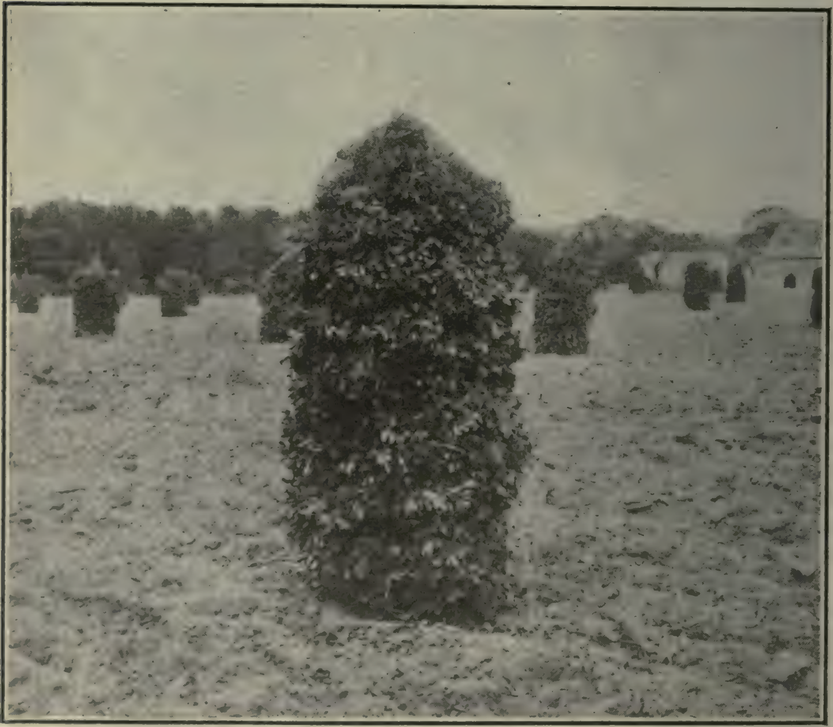

FIGURE 13.—Typical stack of peanuts at the time of completion and before it has settled

the pole by hand, pressing them down, and keeping all the peanuts on the inside next to the pole. (Fig. 12.) Occasionally a bunch should be divided and hung around the pole in order to bind the stack together and to keep the center about 1 foot higher than the outside, so that the stack may shed water. Where the vines are extremely long the center of the stack should be kept high from the start. In order to provide free circulation of air and prevent the possibility of the nuts heating and souring in the stacks, under no circumstances should the stacks be more than 36 to 42 inches in diameter.

As the stack nears completion it should be gradually drawn to a point and a few vines crowded down over the sharpened top of the stake to complete the stack. A little dry grass or weeds may be placed on top of the stack, but too much will have a tendency to prevent circulation of the air through the stack and will interfere with the proper curing of the peanuts. A typical completed stack is shown in Figure 13.

Peanuts are, as a rule, stacked in the field where the crop is grown, but sometimes the vines are hauled to a central point where the stacks are built close together and inclosed with a fence in order that the hogs may be turned into the field to feed on the nuts detached in harvesting.

Peanuts intended for the market should remain in the curing stacks three to six weeks before being picked from the vines. Peanuts cure rather slowly in the stacks, and if picked from the vines too soon the peas have a tendency to shrivel and there is more or less danger of molding or fermenting after picking. Where the peanuts, vines and all, are to be used for stock feed, they should be cured in stacks for at least four weeks before being stored in barns.

PREPARATION FOR MARKET

PICKING

Picking the commercial peanut crop of the United States is done mainly during October, November, and December. Peanuts can be picked satisfactorily only when the vines are dry and brittle, as damp weather causes them to be tough and the pods difficult to detach. If for any reason it is necessary to pick the peanuts when they are damp or before they are fully cured, they should not be stored in large quantities but should be spread thinly on a floor and stirred from time to time until dry. If bagged or stored in bulk before they are fully dry, they will go through a sweating or souring process that renders them unfit for the market or for seed.

Hand picking, as practiced in Virginia and North Carolina in the early days of the peanut industry (fig. 14), is no longer practicable with the commercial crop. A satisfactory peanut-picking machine must remove all of the marketable nuts from the vines with a minimum amount of breakage of the pods. Two types of picking machine are now on the market, one working on the principle of a cylinder grain thresher and the other provided with a wire mesh over which the peanuts are drawn in such a manner that they fall through and are pulled from the vines. The capacity of peanut-picking machines depends upon the make of machine and the condition of the peanuts, about 250 bushels per day being an average. In addition to removing the pods from the vines, the machines have special facilities for cleaning them and taking off the small stems. (Fig. 15.)

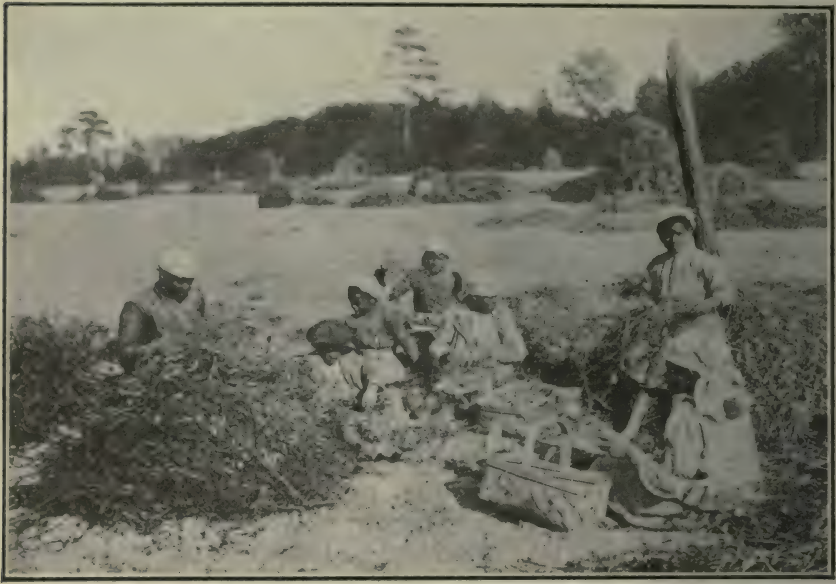

FIGURE 14.—Old-fashioned method of picking peanuts from the vines by hand

In order that no time may be lost by hauling the stacks long distances, the picker is set at a convenient point near the center of the field and in large fields may be moved two or three times to shorten the haul. The entire stack, pole and all, should be brought to the picker, none of the peanuts being wasted by this method, as would be the case if the vines were removed from the poles in the field. The poles can be loosened from the ground by means of a handspike thrust underneath the crosspieces. Two men can then easily load the stacks

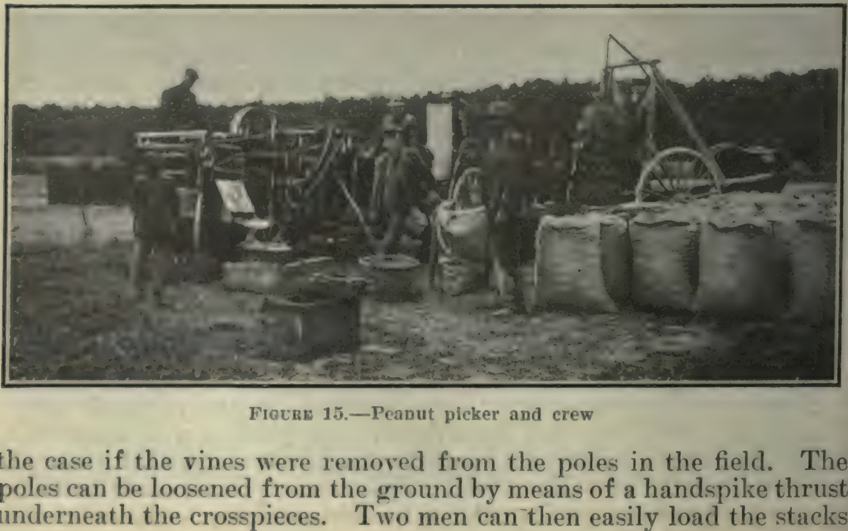

FIGURE 15.—Peanut picker and crew

upon low-wheeled wagons, and during the unloading the poles are drawn out and thrown to one side.

In sections where peanuts are extensively grown, a special 2-wheel cart, as shown in Figure 16, is frequently employed for hauling the stacks to the picker. The cart is backed against a peanut stack, the short chain, attached to the end of the lever, hooked around the top of the stacking pole, and the stack raised free from the ground by drawing down the long end of the lever and securing it under a hook attached to the shaft. The outfit is then driven to the picker, the lever released, and the chain unhooked from the stacking pole. By driving the horse in a trot, an outfit of this kind will move almost as many stacks to the picker as a 2-horse team attached to a wagon with two men to load and unload it. The cart, however, gives best results where the haul is short.

Slow, uniform operation of the picking machine will secure best results as to both quality and quantity of peanuts, and if the vines are either damp or extremely dry the machine will need to be adjusted to suit their condition. The special attachments for recleaning the peanuts as they come from the machine should always be used, even though their use may slow down the work of picking somewhat. Four or five men are required to operate the machine, one to place the peanut vines in small forkfuls upon the feeding table, one to feed them uniformly through the machine by hand, one to handle the peanuts as they are delivered from the machine, one to throw back the hay, and one to attend to the oiling and care of the machine.

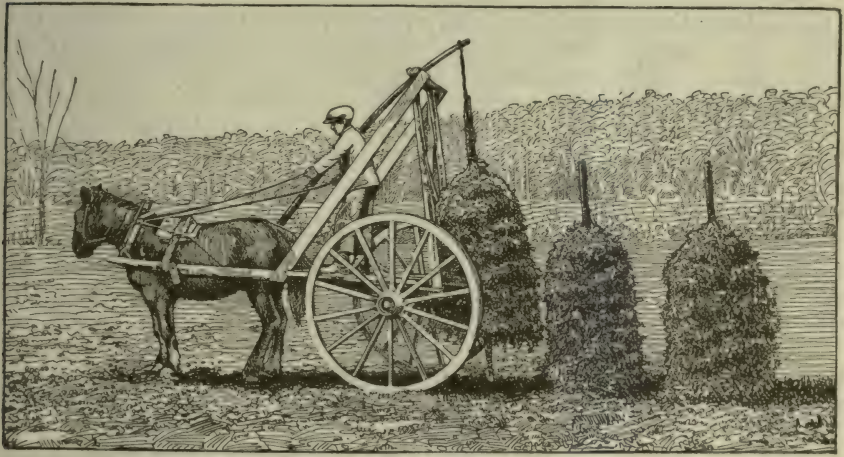

FIGURE 16.—Device used for lifting peanut stacks and moving them to the picker in the field

BAGGING

Some of the peanut-picking machines have a bagging attachment, and the peanuts go directly into standard peanut bags. These are 32 by 36 inches in size and hold approximately 120 pounds of Spanish peanuts. As the bags are filled they are taken from the machine and the opening closed by sewing with a bagging needle and soft twine. The bags are then hauled direct to a barn or storage shed. If on account of shortage of teams the peanuts can not be hauled to the storage place the same day they are picked, the bags should be piled on a foundation of poles and securely covered with canvas or peanut vines, to protect them for a day or two until they can be hauled.

Peanuts as they come from the picker frequently contain more or less moisture and should be stored so as to permit a free circulation of air. The building in which peanuts are stored should have a good roof, and the bags should be fully protected from rain. The bags should not be piled directly upon the ground or on a tight floor, but poles or 2 by 4 scantling should be placed under them to provide ventilation. Great losses occur in the farm storage of peanuts from the ravages of rats and mice, which not only destroy the nuts but by cutting holes in the bags cause serious losses during subsequent handling. Any storage can be made rat and mouse proof by lining it with woven wire the meshes of which are less than one-half inch.

CLEANING AND GRADING

Sometimes the peanuts are ready to market as they come from the picker, but more often there is more or less rubbish, including broken stems, light pods, roots, sand, and small stones, which must be removed before the peanuts are in condition to market. The grading is accomplished by recleaning, during which the trash and light pods are blown out. The peanuts may be again passed through the picking machine, utilizing the cleaning device. In recleaning, the peanuts may be fed through the picker in a steady stream as fast as they can be handled by the cleaning attachment, a heavy air blast being maintained. After being recleaned they are resacked. Each sack is weighed, and the weight and grade are marked upon it. The peanuts are then ready for marketing.

The United States grades of peanuts, issued by the Bureau of Agricultural Economics of the United States Department of Agriculture, have been adopted by the trade associations in certain of the Southern States, based upon the size and the quantity or percentage of first-class kernels that may be shelled from a given sample. Four grades have been promulgated, as follows: Farmers' stock White Spanish peanuts, Farmers' stock Virginia-type peanuts, shelled White Spanish peanuts, and shelled Runner peanuts.

Too much emphasis can not be placed upon the necessity for careful picking and grading of peanuts, particularly if the grower wishes to make use of the facilities afforded under the United States warehouse act for financing purposes.[2]

VARIETIES FOR THE MARKET

At least 9 or 10 more or less distinct varieties of peanuts are grown in this country, but the varieties known as Virginia Runner, Virginia Bunch, and Jumbo furnish the large-podded peanuts appearing on the markets. According to good authority, the Virginia Runner and Virginia Bunch were originally one variety, and the present varieties are the result of selection. Recently the variety known as Jumbo has developed through selection.

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[2] Information relative to the storage of peanuts under the United States warehouse act may be had by addressing the Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D. C.

The Spanish variety, including the White (or true) Spanish, several strains of Improved Spanish, and one or two strains of Small Spanish, is used mainly for shelling and for the manufacture of peanut oil. Large quantities of the large-podded varieties, however, are shelled and enter the shelled-goods market.

In addition to those mentioned above there are several varieties and strains, mainly of local importance, including African, North Carolina or Wilmington, Tennessee White Skin, Tennessee Red Skin, Valencia, and Georgia Red, the last three having red-skinned peas, which are considered undesirable, especially where mixtures appear in shelled goods of the white varieties.

Virginia Runner has a spreading habit of growth and forms pods both at the base of the plant and along the stems. It is rather difficult to dig without losing a few of the peanuts and to stack so that the nuts will not be exposed to the weather. This variety is grown extensively in southeastern Virginia and northeastern North Carolina.

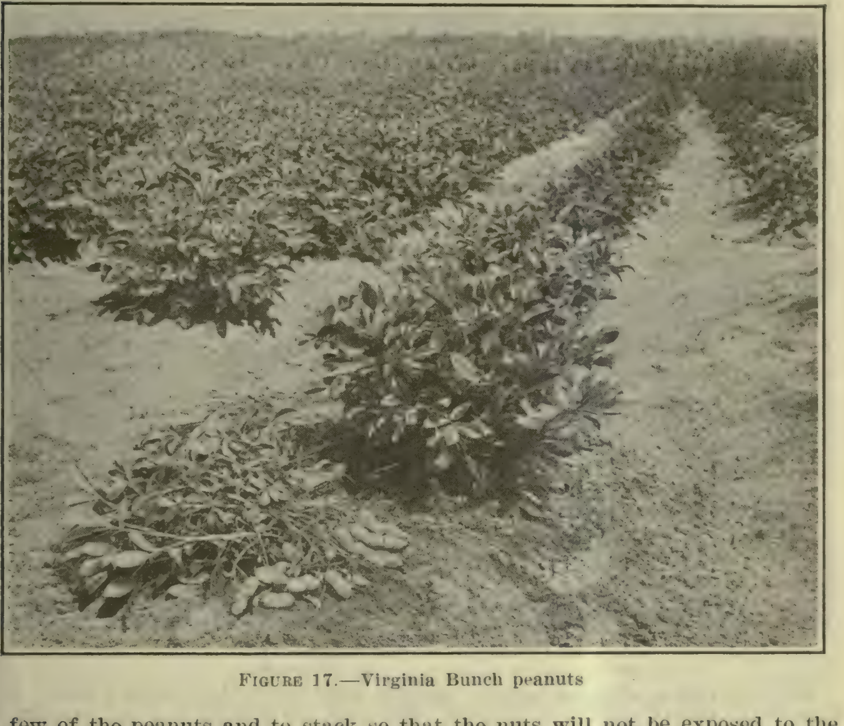

FIGURE 17.—Virginia Bunch peanuts

Virginia Bunch has an upright or bunch habit of growth, and the pods are formed in a cluster around the base of the plant. (Fig. 17.) It is easy to cultivate and is not difficult to harvest.

Jumbo is a comparatively new variety of bunch type, having somewhat larger pods and peas than either the typical Virginia Bunch or Virginia Runner varieties.

Spanish is the most important commercial variety in the South, especially outside of the Virginia-North Carolina district. The medium or true White Spanish, as shown in Figure 18, is adapted for all purposes in the South Atlantic and Gulf coast regions. This variety is of an upright habit of growth, has rather heavy foliage, and the pods cluster close about the base of the plants. It is easy to cultivate and to harvest.

Improved Spanish resembles the regular Spanish, but the vines are more vigorous and the pods and peas are larger.

African, sometimes called Alabama Runner, is a low-growing runner pea, requiring a long season for its maturity. It produces a heavy yield of peas, which are fairly high in oil content, but this variety has not found general favor on the market.

North Carolina, or Wilmington, is a runner pea somewhat resembling Virginia Runner, but is of lighter growth and has smaller pods. Certain characteristics indicate that it may be closely related to the variety known as African. Peanuts of the North Carolina variety are used both for shelling and for small-sized vending stock.

Tennessee White Skin belongs to the Valencia type and has long and slender pods with several white-skinned peas in each. It is a rather desirable variety for shelling.

Tennessee Red Skin is similar to Tennessee White Skin except that its peas are red. It is not extensively used for shelling but is sold locally for roasting in the shell.

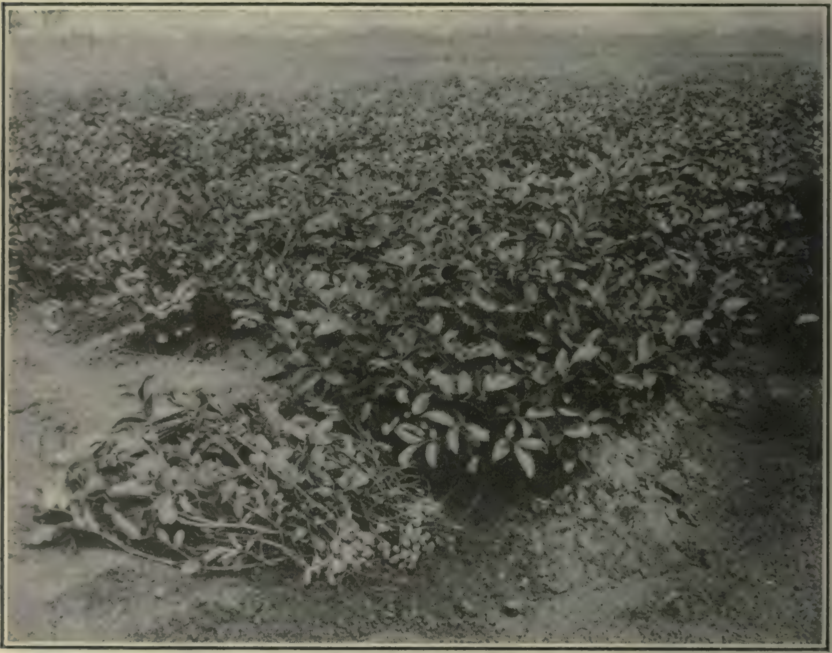

FIGURE 18.—Spanish peanuts

Valencia has a vigorous upright growth, with the pods clustered about the base of the plants, similar to Spanish. The peas are reddish and not considered desirable for shelling.

Georgia Red, sometimes called Red Spanish, is another variety closely related to Valencia. Its pods are short, usually containing two or three light-red peas.

MARKETING

Peanuts should always be sold by actual weight rather than by the bushel. Considerable confusion arose in the past from the use of the bushel as a measure for handling and selling peanuts. The large-podded Virginia varieties will, as a rule, weigh about 22 pounds, the Spanish 30 pounds, and Runners 28 pounds to the measured bushel, but these weights are not constant and vary with locality, grade, and condition of the stock. If sales are conducted on the basis of tons or hundredweight and according to standard grades, both buyer and seller will have in mind a definite standard.

Peanut-cleaning factories and oil mills are essential in the preparation of the peanut and its products for the retail market. As the many and varied uses developed for peanuts require intricate and expensive machinery, this work can not be done to advantage on the farm. Therefore, when the farmer has recleaned and graded his crop and delivered it to the shipping point or to the factory in the best possible condition, his connection with the work ends.

PEANUTS AND BY-PRODUCTS AS STOCK FEED

Peanuts are exceptional among southern farm crops in that every part of the plant and all by-products resulting from the factory processes through which peanuts pass can be utilized to good advantage, mainly for stock feeding. Peanut hay and the light or inferior pods constitute the by-products on the farm; hulls, press cake, and meal result from the manufacture of peanut oil; hulls, shrunken and inferior kernels, germs, and fine particles of meats are by-products of the cleaning factories; and considerable quantities of germs, red skins, and inferior particles of meats result from the manufacture of peanut butter and confections.

Peanut hay, or the vines from which the pods have been removed, was at one time allowed to go to waste, but now has considerable market value and hundreds of carloads are sold. Although it does not contain as much protein as alfalfa, clover, cowpea, or soybean hay, it may be used where a legume hay is desirable. It is considerably better than stovers and grass hays as a source of protein. Where the vines are properly cured in stacks, the hay will come from the picker with a bright color. Sufficient attention has not been given by the manufacturers of peanut-picking machinery to providing proper attachments for handling and cleaning the hay. If these machines were provided with better facilities for separating the dirt from the hay, less difficulty would be experienced in feeding it. By proper manipulation of the picking machines now in use much of the sand and dust can be separated from the hay and its value increased. As a rule a baling machine is employed either in conjunction with the picker or following behind and packing the peanut hay into bales. Care must be taken in baling to mix the leaves and stems so that the product will be uniform. Peanut hay should be baled when dry and the bales stored where they will not be exposed to the weather.

Moldy peanut hay is unfit for feeding purposes, but hay that has been properly cared for may be fed to all kinds of livestock. In feeding to mules and horses it should be fed in racks or wire-bottom mangers, in order that any sand or dust may sift through. Cases are on record where both horses and mules have been injured by feeding either moldy or extremely dusty peanut hay, the symptoms frequently being similar to those of ordinary colic.

All light or inferior peanuts removed in recleaning and grading may be used for feeding hogs on the farm, or they may be ground, shells and all, mixed with other ingredients, and used as dairy, poultry, or hog feed.

With the establishment of the peanut-oil industry in the Southern States a line of practically new by-products has appeared upon the market, peanut cake and peanut meal being the most important. In the production of the highest grade virgin peanut oil abroad the nuts are shelled and hand picked just the same as for the confectioners' trade, and the press cake resulting is of a very high grade. Where the nuts are crushed, shells and all, a lower-grade cake and meal results, but even this makes a highly concentrated feed. When fed to dairy animals peanut meal does not give the milk any peculiar flavor, and it can be fed continuously to hogs without any injurious effects except a slight softening of the flesh. Peanut meal made from shelled nuts is more desirable for hog feeding than that which includes the shells.

Both peanut meal and the shells resulting from cleaning peanuts for oil making find a ready use in the manufacture of mixed dairy feeds. The ground peanut hulls are also used for polishing tin plate. The greater part of the shells, however, are still used as fuel in the boilers of the cleaning plants.

In feeding pure peanut meal, reasonable precaution should be taken as regards the quantity fed, on account of its high protein content. The safest plan is to mix it with other feeds, forming a balanced ration.

Formerly the greatest use for peanuts in the Gulf coast region was for feeding to livestock on the farms. The production of peanuts for the market in that section has been a transition from the stock-feeding phase. While there may be disadvantages connected with the feeding of peanuts to hogs, the fact remains that they are one of the most important hog feeds on southern farms.

There is no doubt that peanuts have a pronounced softening effect upon the carcasses of hogs. Numerous experiments have been conducted by the United States Department of Agriculture in cooperation with State experiment stations to determine the extent to which this effect can be overcome by finishing the hogs on corn and other hardening feeds and also to study other phases of the soft-pork problem. From the results so far available the following facts may be mentioned: (1) There is no means by which the hogs that will kill soft may be detected until the carcasses have been chilled. (2) As a rule, peanut-fed pork will shrink more in the curing and smoking processes than that produced on corn. (3) It is beyond question that the table quality and the flavor of pork, both fresh and cured, that has been produced in part on peanuts, are markedly improved. (4) The market discrimination against peanut-fed hogs is based largely upon the oily, unattractive appearance of the fresh cuts, lard, and sausage and the difficulty in selling these products. The poor slicing quality of the bacon is also an important consideration.

Decision as to the use of corn or peanuts in the growing and fattening of hogs on southern farms must rest upon the profit per acre that can be made by each method. While no reliable figure is available, it is estimated that the average discount on peanut-fed hogs when sold is approximately 2 cents a pound on the live-weight basis. In order for pork production on peanuts to be a profitable practice, it must represent an economy sufficient to offset this difference in market value, in comparison with feeds that produce firm hogs. It should be borne in mind, however, that peanuts are not the only feed that produces soft pork.

Where peanuts are grown exclusively for feeding purposes successive plantings should be made; also more than one variety should be used. The Spanish is undoubtedly the best all-round variety for feeding purposes, but has the disadvantage that the seeds are liable to sprout in the ground if wet weather occurs after they are mature. The Georgia Red (sometimes called Red Spanish) has the characteristic of remaining in the ground without sprouting throughout the autumn, and sometimes until nearly spring, and for that reason it is especially adapted for hog feeding. The variety known as African is also a good hog-feeding sort, as it matures late, produces a large number of pods, and keeps well in the ground.

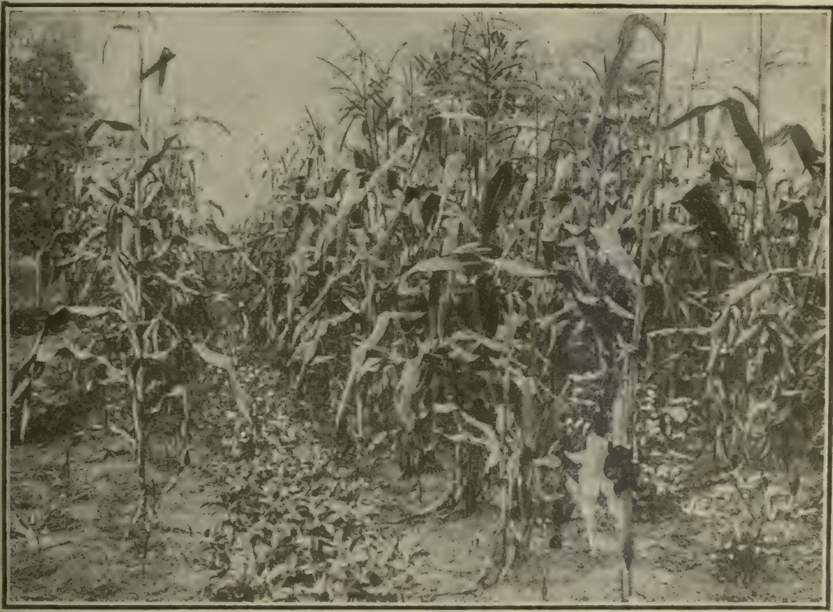

FIGURE 19.—Peanut growing between rows of corn

Spanish and similar varieties having an upright habit of growth are frequently mowed for hay, after which the hogs are turned in to harvest the peanuts. Another method is first to mow the tops for hay, dig and stack the greater part of the peanuts, and then turn in the hogs. Because of their low spreading habit of growth the Virginia Runner, North Carolina, and African are not adapted for handling in this manner. In many parts of the South peanuts are planted between the rows of corn, as shown in Figure 19.

VALUE AS A MONEY CROP

Too much can scarcely be said in favor of the peanut as a money crop for southern farms wherever the character of the soil, the climate, and the local conditions are adapted to its production. The demand for peanuts is increasing as new uses and a wider market are found. In order that the grower may know where he stands as regards profits derived from his crop he should keep a reasonably accurate account of all items of expense entering into its production.

It is assumed that of the cost of growing a single acre is known, the cost for the crop on any given farm may be determined with reasonable accuracy. Local conditions determine to a certain extent the cost of growing peanuts, and actual cost figures can not be given in a publication for use throughout the peanut territory of the United States. The following items are those usually entering into the cost of production:

1. Rental of land or interest on the value of the land.
2. Supervision and overhead costs, including interest on investment in tools, equipment, and storage houses and their repair and upkeep.
3. Fertilizers, lime, or marl.
4. Seeds.
5. Bags and stacking poles.
6. Labor involved in the following operations:
   - *a.* Plowing and fitting the land.
   - *b.* Marking land, spreading fertilizers, and planting seed.
   - *c.* Cultivation.
   - *d.* Hand hoeing.
   - *e.* Digging and stacking.
   - *f.* Picking.
   - *g.* Hauling to market.
7. Miscellaneous expenses, including any preventable losses that occur from the ravages of rats and mice and any discounts or dockages due to peanuts not conforming to represented grade. These do not form a part of the actual growing costs and should be figured rather as losses.

The average yield of peanuts harvested as nuts for the entire United States during the 4-year period 1926–1929 was 728 pounds per acre, or approximately 33 bushels per acre if expressed in terms of the large-podded varieties, or about 24¼ bushels of the Spanish type. This, however, includes a large acreage grown as a secondary crop and where cultural conditions were such that high yields were seldom obtained. The figures for Virginia and North Carolina for the same period averaged between 900 and 1,100 pounds per acre, or about 250 pounds greater than the average for the United States. Under the best conditions, yields of 1,400 to 1,600 pounds are frequently secured.

Definite figures as to the market value of an acre of peanuts change from year to year. If the yield and grade are known, it will be an easy matter to apply current prices and, allowing a reasonable value for the hay and waste products, compute the value of the product of an acre. By deducting the cost of growing, net profits may be obtained.

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U. S. GOVERNMENT PRINTING OFFICE: 1931

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U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1657

THE GREAT BASIN WIREWORM IN THE PACIFIC NORTHWEST

1862 1889

THE GREAT BASIN WIREWORM is costing the farmers of the Pacific Northwest millions of dollars annually in those areas receiving less than 15 inches of precipitation annually. This pest seriously cuts down the stand of both winter and spring grain in the early spring. Damage from this wireworm is especially noticeable in a year with a long cold spring and severe winter injury to the fall-sown grain.

Its long life, together with its ability to withstand drought and starvation, makes this pest hard to control, once it gets a start. The vital time in its life history is during the first summer after hatching from the egg. At this time it must have growing, succulent rootlets of grain or weeds to survive. A brood is being hatched each year. It is therefore essential that clean summer fallowing be practiced conscientiously year after year. A weedy summer fallow for only one season will usually result in damage from wireworms for several years. Clean summer fallow means the killing out of every weed during the whole season.

Absolutely clean summer fallow is the only efficient control for the Great Basin wireworm.

Washington, D. C. **Issued February, 1931**

THE GREAT BASIN WIREWORM[1] IN THE PACIFIC NORTHWEST

By M. C. Lane, *Associate Entomologist, formerly of the Division of Cereal and Forage Insects, Bureau of Entomology*

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IMPORTANCE AND DISTRIBUTION

The GREAT BASIN WIREWORM has caused consistent losses to the wheat crop of the Pacific Northwest running into several millions of dollars annually. This wireworm is native to the dry-farming areas of the Columbia and Snake River Basins in Washington, Oregon, and Idaho, where the normal annual rainfall does not exceed 15 inches. (Fig. 1.) Soon after the start of wheat raising in this region some 40 years ago, the Great Basin wireworm changed its feeding, from the bunch grasses on which it originally fed, to include the wheat and other grains.

It has increased in abundance under these more favorable food conditions and has readily adapted itself to the system of summer fallowing generally followed in this great dry-farming area.[2]

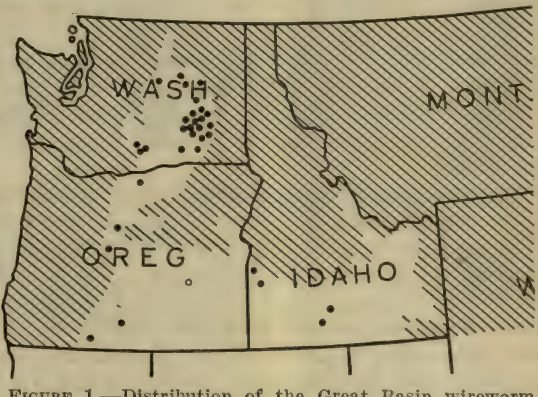

Figure 1.—Distribution of the Great Basin wireworm in the Pacific Northwest. The dots represent specific occurrences. The unshaded portion represents the area with an average of less than 15 inches of precipitation annually

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[1] *Ludius pruininus* Horn, var. *noxius* Hyslop; order Coleoptera, family Elateridae.

[2] For information on the best farm practices adapted to the region under discussion, see the following publications: United States Department of Agriculture Farmers' Bulletin 1545, Dry-farming Methods and Practices in Wheat Growing in the Columbia and Snake River Basins; Washington Agricultural Experiment Station Bulletin 192, A Review of the Agriculture of the Big Bend Country, and Popular Bulletin 135, Farming in the Big Bend Country.

The precipitation in this area occurs during the fall, winter, and spring months, much of it in the form of snow. The months of June, July, August, and September usually are very dry. The dry-land wireworms have become adjusted to this condition so that they feed only during March, April, and May, or as long as the temperature remains relatively cool, and there is moisture in the surface soil. Wireworms of this species are fairly evenly distributed in the soil of the grainfields over all the area infested. To be sure, damage sometimes becomes more apparent in spots, but this is because conditions of soil temperature, moisture, or texture are generally more favorable in these places for the wireworm to work and kill the stand of grain.

EXTENT AND NATURE OF INJURY

The Great Basin wireworm does considerable damage every spring (1) to the winter wheat, especially to stands that have not survived the winter in a thrifty condition, and (2) to the spring wheat which is being seeded about the time the wireworms are becoming active in the soil.

They travel the path of least resistance in the soil, which is usually along the drill row, feeding on the kernels and plants. One wireworm can account for the death of several plants, and the average loss to the grain in districts infested with this wireworm is done by only one or two wireworms per square yard.

Injury by wireworms to winter wheat varies with the weather conditions during the winter and spring, the injury being more noticeable in years of severe winter killing. The wireworms will thin out the stand of grain in the spring, often necessitating the reseeding of winter-wheat fields to spring grain. This is especially true in seasons when the weather remains cool and wet for a considerable period. A warm spring that will allow the wheat to grow and stool out rapidly will largely offset any noticeable damage which may be done by wireworms, even though they may be feeding on the plants as usual.

In the spring-seeded grain the wireworms attack the kernels as soon as planted, in some cases actually preventing germination. They also attack the underground portions of the wheat plants after sprouting, killing out the stand in spots. After the plants begin to stool the damage done by wireworms becomes much less noticeable. On the advent of hot weather in May and June, when the soil dries out below the crowns of the plants, the wireworms descend deeper into the soil, and suspend feeding until the following spring.

The injury caused by wireworms is very distinctive. They burrow into the kernels of grain in the spring, leaving only the seed coat in the soil. They also attack the underground portions of both the winter and spring wheat plants, boring through the leaf sheaths and into the stems in such a manner as to cut off the growing point. The leaves and roots remain alive but in a dying condition for several days, the stems eaten by wireworms having a peculiar shredded appearance. After the plant has begun to tiller, any one of the growing points of the individual tillers may be cut off by wireworms, but without noticeable damaging effect, since the remaining growing points maintain development. This manner of attack distinguishes the damage done by the Great Basin wireworms from that caused by "false" wireworms,[3] as the latter wholly consume the grain and plants as they feed. False wireworms (fig. 2, *a*) are the young or larval stage of the large, black, so-called "stink" beetles to be found crawling around in the fields during the greater part of the growing season.

DESCRIPTION OF THE STAGES

EGG

The eggs are pearly white, nearly round, being only slightly longer than wide, and so tiny in size as to be almost invisible to the naked eye. They seem to bear a sticky substance that causes small particles of soil to adhere to them. The eggs are easily dried out and will not stand exposure to air conditions for more than a few minutes.

LARVA

The newly hatched young or larvae are pure white, with dark mandibles or jaws, and are barely one-sixteenth of an inch in length when emerging from the egg. After feeding and molting several times they become golden yellow in color, and they obtain a length of three-fourths of an inch when full grown. (Fig. 3, *b*, *c*, and *d*.)

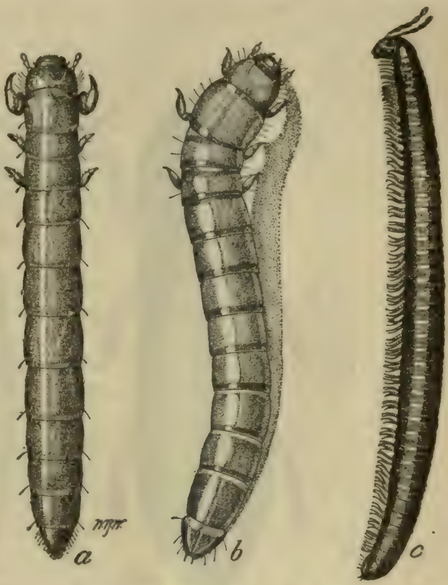

FIGURE 2.—These are likely to be mistaken for wireworms: *a*, False wireworm; *b*, mealworm; *c*, "thousand legger." About 2½ times natural size

PUPA

The pupa or transition stage is white, becoming dark yellow when the beetle is almost ready to emerge. The beetle is smoky white at first, but very soon becomes black.

ADULT

The adult beetles (fig. 3, *a*) of the Great Basin wireworm are jet black, slender, and measure about one-half inch in length. They are popularly known as "click beetles" or "snapping beetles," these names being derived from their habit of snapping the forepart of the body when placed on their backs or held between the fingers. Beetles from the southern portions of their range in Oregon and Idaho average slightly larger and more robust. The appearance

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[3] Various species of the genus Eleodes. For further information concerning false wireworms, see the following publications: Journal of Agricultural Research, volume 22, pages 323–334, Biology of *Embaphion muricatum;* volume 26, pages 547–566, Biology of the False Wireworm *Eleodes suturalis* Say; and Idaho Agricultural Experiment Station Research Bulletin 6, False Wireworms Injurious to Dry-Farmed Wheat and a Method of Combating Them.

of the sexes is similar, but the female is slightly more robust than the male, having shorter antennae, and with segments not so much flattened as in the male.

LIFE HISTORY AND HABITS

The adult beetles (fig. 3, *a*) of the Great Basin wireworm normally emerge from the soil when the temperature at a depth of 8 inches reaches about 55° F. This condition generally follows a two or three day period of warm weather from May 1 to May 15, in the latitude of central Washington. Male adults fly freely on sunny days when temperatures are above 65° F., but their total period of life usually does not exceed three weeks. The males have been observed at rest on plants but never have been seen to feed during their short period of existence. Observations during several seasons have never disclosed a female adult in flight and rarely has the female been found abroad in the fields. She apparently remains quietly under a clod, until found by the male, and probably migrates only short distances by crawling on the surface of the ground.

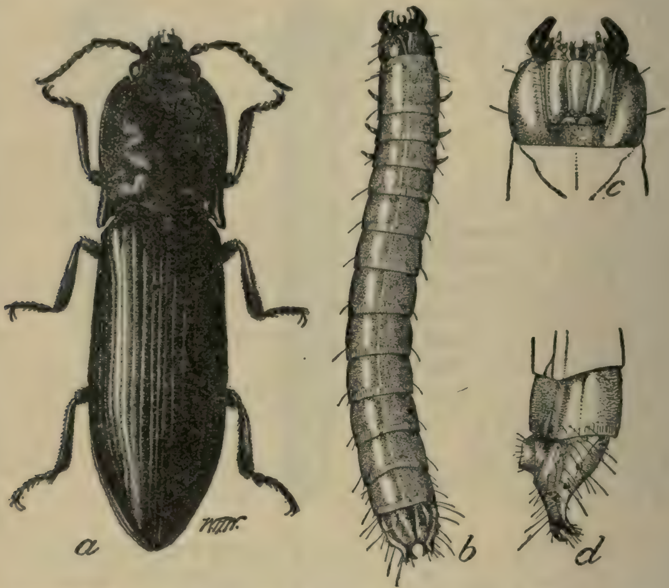

FIGURE 3.—The Great Basin wireworm: *a*, Adult; *b*, larva; *c*, under surface of head of larva; *d*, side of last segment of larva. *a*, *b*, About 5 times natural size; *c*, *d*, about 12 times natural size

After mating the female burrows down to deposit her eggs in the cool, moist soil at a depth of several inches. All the evidence accumulated tends to show that the eggs are deposited in one place and within a relatively short period.

In experiments made in an underground laboratory the time passed before egg laying occurred was found to be about three weeks, and the egg stage lasted about four weeks. These periods varied with individual females. Most of the females laid about 350 eggs, but some of them laid over 500 eggs each.

The eggs of the Great Basin wireworm hatch during the latter part of June, and the young wireworms gain their first food from the living rootlets of grain and weeds. They increase in size very slowly, attaining a length of only about one-fourth of an inch the first year. Wireworms usually molt or cast their skins twice a year, though some individuals molt only once, while others go through as many as four or five molts in a season. Molting does not seem to take place during the active feeding season, the first molts occurring not earlier than June, others coming in August, and some as late as September. In the laboratory experiments half to full grown larvae that were not given any food throughout the season molted the same number of times as those fed regularly, and after several years without perceptible feeding some of these starved wireworms pupated and became adults.

The shortest time that this wireworm takes to complete its growth is not less than three years, and this is apparently the usual period for the greater number in each generation. However, under unfavorable conditions of food and soil these worms often do not transform to beetles the third year, but remain unchanged for years or until the conditions are suitable for pupation. Under laboratory conditions a few of these wireworms have remained in the larval state for 10 years and these individuals have molted at least once each year.

The wireworms usually change to the pupal stage during the third year of their life in late July and August, at a depth of about 7 inches in the hard, packed soil just below the plow line. The average depth of plowing in this region is 5 inches. The change to the pupal stage takes place in the soil in a vertical cell which is slightly larger than the pupa. The beetle emerges from the pupal skin after about 10 days but remains in the cell until the following spring, when it burrows out of the soil. The beetles are not hurt in the least by freezing temperatures during the winter. The 1, 2, and 3 year old larvae spend the winter deep enough in the soil to avoid freezing temperatures and then work their way to the surface in the spring as soon as the last frost is out of the ground.

Probably the minimum length of the life cycle of this wireworm, from the egg to the beetle ready to lay eggs, is four years.

NATURAL ENEMIES

The natural enemies of wireworms are comparatively few and can not be depended upon to control them. Great Basin wireworms are very rarely attacked by other insects, only a few insect enemies being known. Birds are fairly effective enemies of the beetles of this wireworm during its emergence period in the spring. Examination of the stomach contents of birds collected during the period of adult emergence has revealed remnants of great numbers of beetles. Any means of protecting and increasing the abundance of bird life in the dry-farming areas is to be highly commended, especially in the case of the Columbian horned lark (*Otocoris alpestris*), commonly called " wheat bird " or " dust bird." This native bird is found over nearly the same range as the Great Basin wireworm, and nearly all of the stomach contents of these birds examined during the spring emergence of the wireworm adults showed that they contained remnants of from 1 to 30 of these beetles. The Bureau of Biological Survey reports that 40 species of birds are known to feed on species of the genus Ludius, to which the Great Basin wireworm belongs, and that in general birds prey freely upon wireworms and their parent click beetles.

CONTROL MEASURES

CLEAN SUMMER FALLOW

The critical period in the life of this wireworm is in the first year of its existence immediately after emergence from the egg. This occurs in the last part of June or early in July when the tiny young larva must have growing, succulent food in order to survive under the very dry conditions met with in its native home at this season. Usually, at this time of the year there are two different soil conditions to be found in the fields inhabited by wireworms.

(1) There is a very unfavorable condition where the current year's crop of wheat is approaching maturity for harvesting during July and early August. All available moisture in the soil at such a time has been taken up by the crop to a depth of several feet, leaving the ground hard, packed, and supporting hardly any succulent vegetation. Under these conditions the first-year wireworms have a very hard struggle and little chance of surviving their first season.

(2) There is a more favorable condition in such spring-plowed fields as are lying fallow for the next season's seeding. If the summer fallow is plowed early and properly there should be enough moisture under the surface mulch to permit the survival of a considerable number of first-year wireworms. However, the best farm practice under a summer-fallow system calls for frequent cultivation to keep down weed growth[4] (fig. 4) and thus prevent any loss of moisture or nitrates from this cause. Doing away with weeds also acts against the wireworms by destroying their only available food supply, thus preventing them from surviving the first season. If a summer fallow is allowed to become in any degree weedy (fig. 5) this will permit a considerable population of wireworms to live through the first summer and be ready to take advantage of the abundant food furnished by the wheat crop of the next spring. After they have entered their second year, it is relatively easy for the wireworms to adjust themselves to almost any unfavorable condition and still survive. A weedy summer fallow for only one season would mean several years of damage from wireworms, because of their long life and ability to survive after their first season. Hence the first and most important control recommendation against the dry-land wireworm is this: Always keep the summer fallow absolutely clean.

SPRING HARROWING NOT RECOMMENDED

It has been a common practice for many years to harrow the winter wheat in the spring as soon as frost is out of the ground. This is intended to break the hard surface crust and enable the

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[4] The three most important weeds occurring on summer fallow in this dry-land region are Russian thistle (*Salsola pestifer* Nels.), tumbling mustard (*Sisymbrium altissimum* L.), and tumbleweed (*Amaranthus graecizans* L.).

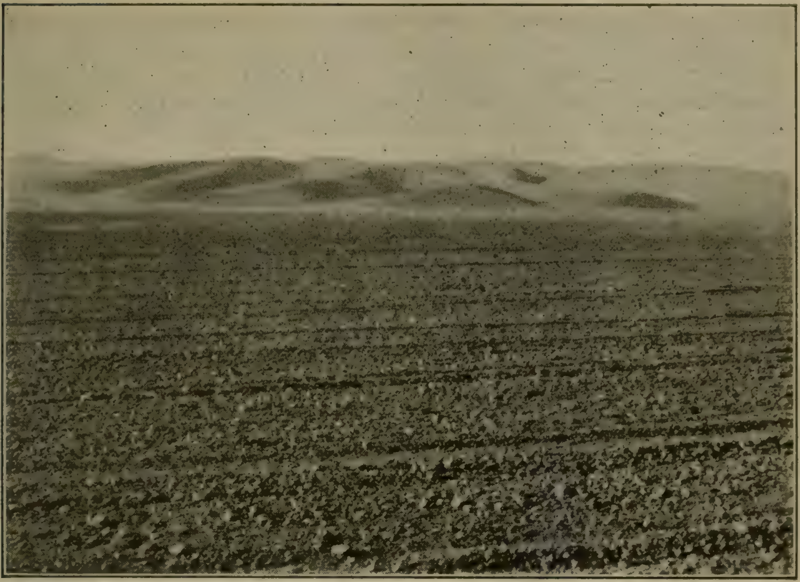

FIGURE 4.—A clean summer fallow which starves out the newly hatched wireworms in their first season. The hills in the background are all farmed and the grain is harvested with combines

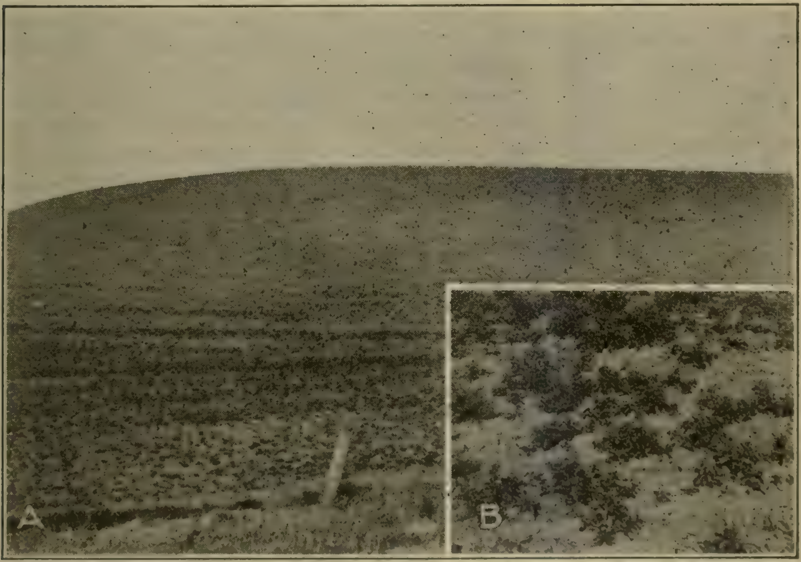

FIGURE 5.—A, A weedy summer fallow which allows the newly hatched wireworms to obtain food and survive their first season. The growth is mostly tumbleweed, with some Russian thistle. B, Close-up view of a weedy summer-fallow field. Enough newly hatched wireworms will survive their first season under these weeds to keep up a damaging population

plants to grow better. As a matter of fact, experiment-station investigations have shown that such harrowing is unnecessary and often is actually injurious to the young plants in the spring. This harrowing merely loosens up the soil and allows the wireworms more easy access to the plant stems. Therefore, the second general recommendation for control is: Do not harrow winter wheat in the spring.

EFFECT OF SEED DISINFECTION ON WIREWORMS

Copper carbonate dust for disinfecting grain for smut has come into use in recent years and where wireworms are present this treatment has several features to recommend it over the old, wet bluestone or formaldehyde dipping treatments. Treating seed wheat with dry copper carbonate seems to produce more vigorous and faster growing stands of wheat with less injury to the seed. The better and quicker germination shortens the time before tillering when the wireworms can cause serious damage to the slender stems, and the thicker, more thrifty stands of spring wheat obtained from dry-treated seed are less hurt by the thinning caused by the wireworms. Hence the third recommendation is apparent: Treat seed with dry copper carbonate to prevent smut.

PLANT SEED MORE THICKLY IN WIREWORM-INFESTED LAND

The recommendation of planting more seed to offset damage by pests is very applicable in the seeding of spring wheat where the wireworms are abundant. The use of slightly more seed in areas where wireworms have been known to do serious damage in the past is a good and cheap method of overcoming the thinning of the stand by wireworms. Experiment-station results have shown no injurious effects from heavier seeding even in dry years. As the average damage from wireworms to spring grain is from 5 to 10 per cent, it is not necessary to use over 10 pounds of additional seed per acre for this purpose. Therefore the fourth recommendation should be: Use seed enough in the spring to allow for some thinning by wireworms.

CHEMICALS OF NO AVAIL AGAINST WIREWORMS

Chemicals of various sorts have been tried out against wireworms on these vast dry-farming areas, both in connection with seed treatment for smut control and as poisons or repellents to the wireworms themselves. No treatment of this sort would be effective in the fall-sown winter wheat, as the damage is done to the plants in the following spring. In the case of spring wheat no chemical has yet been found that is effective enough as a poison or repellent to be of practical use. Some chemicals retard the germination of grain, and some act merely as repellents while on the grain itself; but all are ineffective to prevent damage by the wireworms to the resulting plants. In the final analysis, any such chemical is too expensive to use over the vast areas involved in damage caused by Great Basin wireworms.

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U. S. GOVERNMENT PRINTING OFFICE: 1931

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - Price 5 cents

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1658

FARM WATER POWER

1862 1889

MANY HAVE TRIED to obtain cheap power from small streams. Some have succeeded and are well satisfied. Others have had indifferent success and for economic or other reasons have partially or completely abandoned their plants.

This bulletin describes and illustrates a number of typical farm water powers. Attention is directed to the importance of competent study of each project, a well-conceived plan, suitable equipment, good construction, and proper maintenance. Economic losses, often unnoticed, are caused by undersize line wires and inadequate or obstructed waterways. Water which does not reach a wheel, whatever its efficiency, and head which is lost in the channel to and from the wheel contribute no power.

This bulletin supersedes Farmers' Bulletin No. 1430, Power for the Farm from Small Streams.

Washington, D. C.

Issued February, 1931
Slightly revised November, 1933

FARM WATER POWER

By GEORGE M. WARREN, *Associate Hydraulic Engineer, Bureau of Agricultural Engineering*

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INTRODUCTION

MANY PERSONS BELIEVE that the energy in flowing wells, hillside springs, running streams, and waterfalls can be easily and cheaply converted into useful power. Some consider it a simple matter to pipe the flow to an inexpensive water motor. Others see support for their belief in commercial power companies which are constantly extending their lines and supplying, at diminishing cost, electric current for both city and rural needs.

There is tendency to underestimate the quantity of water and the expense usually necessary to obtain worth-while amounts of power. Investigations by the Department of Agriculture indicate that numerous farm water-power plants have only partly met the expectations of their owners and that some plants have fallen into disuse. The main reasons why owners have not obtained greater success are:

(1) Failure to realize the technical nature of the undertaking and the importance of having full field data from which to make suitable designs and plans.

(2) Desire of owners to develop their own projects, to exercise their ingenuity, and to experiment with homemade equipment or old parts often obtained from a junk dealer.

(3) Overestimating the amount and constancy of the power obtainable from the natural flow of a stream.

(4) Inadequate channel capacity for the operation of the machinery near its rated speed and capacity.

(5) Using line wires too small for the distance, resulting in excessive drop in the voltage.

(6) Necessity of more attention and expense than was anticipated to keep channels and trash racks clear and machinery in good operating condition.

(7) Changes of farm ownership.

The amount of power that can be obtained from a stream depends upon the quantity of water applied to the water wheel or turbine, the height which the water falls in such application (called the head), and the efficiency with which this mechanical power is converted into electrical power and then distributed for use.

The output of the generator is expressed in kilowatts, one kilowatt being equal to 1,000 watts. The number of watts required by electrical appliances such as motors, washing machines, heating units, and lights are usually marked on the appliance or given in the literature describing them. The energy requirements of a few such appliances are given on page 22.

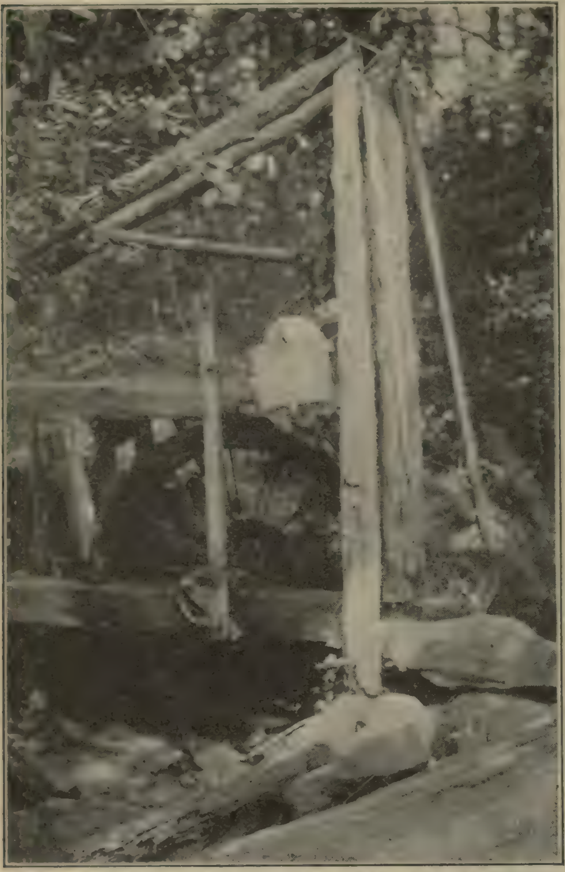

FIGURE 1.—Inexpensive overshot wheel and homemade counterweight rocker arm with draft wire for transmitting the power. Virginia

In this bulletin a number of typical water-power plants are first described. These descriptions will give the reader a general idea of the types of structures and equipment in common use, their cost, and what work the plants accomplish. The accompanying illustrations show how the equipment is installed. These descriptions are followed by a discussion of the design of farm water-power plants including the determination of the quantity of water available and the head, the making of power estimates, and construction details such as dams, water wheels, and the various accessory equipment. With the information contained in the following pages one should be able to determine the power possibilities in a given stream and just how he should proceed in order to obtain advantage from them.

TYPICAL PLANTS

Favorable natural conditions often make it possible to obtain a little power for pumping and like uses by setting up simple apparatus as shown in Figures 1 and 2. Sometimes it is feasible for a farmer to have his own hydroelectric plant. A homemade plant in Pennsylvania, built in 1924 at a total cost of $625 including line and house wiring, consists of an 8 by 2 foot steel overshot wheel costing $225 and a ½-kilowatt generator (second hand) which cost $5. The machinery is in a plain frame house 12½ feet square with concrete foundation and is run day and night on the discharge from a hilly drainage area of 1.9 square miles. A simple log dam (fig. 12, A) diverts water to the wheel.

A similar but more costly plant in which the machinery is started and stopped from the dwelling 800 feet away by means of a windlass and draft wires to the inlet gate is shown in Figure 3. A cross section of the dam is shown in Figure 12, C.

A plant installed under unusually favorable conditions by an Ohio farmer in 1927 is shown in Figure 4. Although the head is only 4 feet, this deficiency is offset by an abundance of water and the fact that the distance to the buildings is but 100 feet.

Parts of the works of old mills can sometimes be used to advantage as is shown in Figure 5.

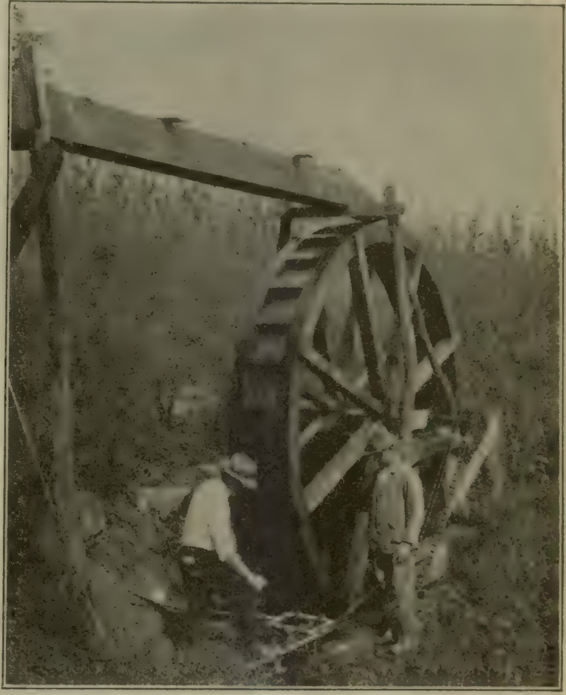

FIGURE 2.—Simple wooden flume and overshot wheel with chain drive to a pump lifting spring water to a mountain home. North Carolina

Sometimes several farmers can cooperate and thus obtain the benefit of better construction and equipment than would be possible for one. A fireproof, mutually owned plant in Pennsylvania, built in 1923 to supply current to three farms having five families, is shown in Figure 6. A cross section of the dam is shown in Figure 12, F.

Another mutually owned plant in Pennsylvania, built in 1923 to supply current to six farms having nine families, is shown in Figure 7. A section through the turbine pit is shown in Figure 8 and a cross section of the dam is shown in Figure 12, G.

The plant shown on the cover page was built in Illinois in 1925 and cost $3,000 including the 2,000-foot power line of No. 4 gauge wire. This plant has a 15-inch vertical shaft turbine rated, under an 8-foot head and full gate, to make 229 revolutions per minute, to require 351 cubic feet of water per minute, and to produce 4.37 horsepower at the wheel. The method of stepping up the turbine speed is typical of similar farm plants and is shown in Figure 9.

Overshot wheels revolve much less rapidly than do turbines, and a different method of drive is employed to step up the speed. Ordinarily, a master spur wheel, which is keyed to the horizontal axle of the water wheel, meshes with a small pinion on a jackshaft to which is fastened a large iron or wooden pulley carrying a belt to a small pulley on the generator. This method of stepping up the speed, excepting substitution of chain drive for spur-gear drive, is shown in Figure 10.

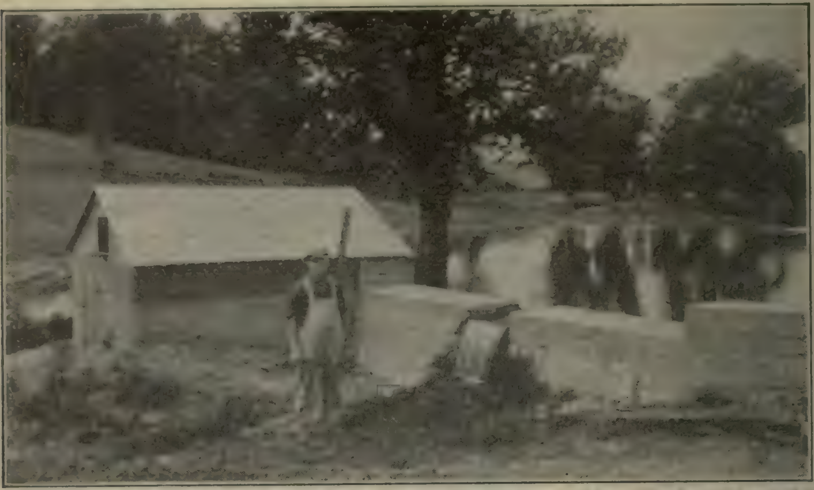

FIGURE 3.—Hydroelectric plant built in Pennsylvania in 1925. Drainage area 2.4 square miles, head 6.9 feet, steel overshot wheel 6 by 2½ feet, generator one-half kilowatt, power house 13 by 15 feet. Cost of machinery $385, materials $325, labor $356, wire $64, miscellaneous $128, total $1,258. Estimated cost of current, including interest, depreciation, taxes, insurance, attention, and repairs, $174 per year

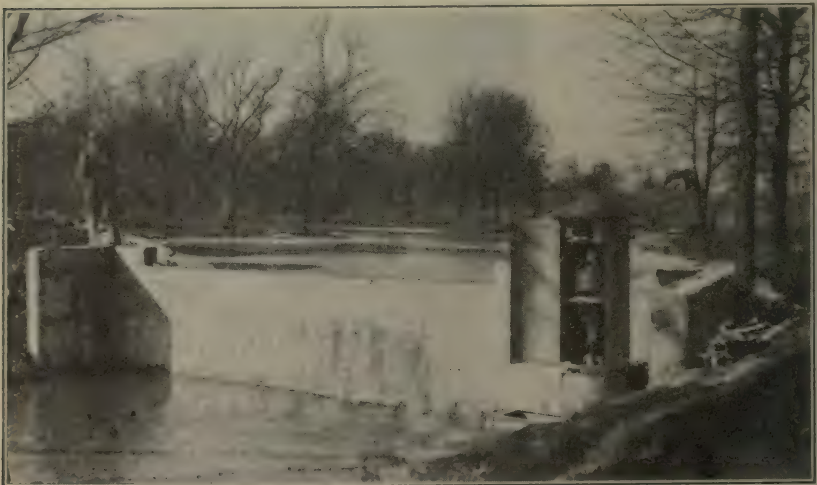

FIGURE 4.—Shop-made self-contained hydroelectric unit consisting of a 12-inch propeller-type turbine, 1-kilowatt generator, governor, and switchboard in a steel plate housing 2⅛ feet in diameter and 8 feet in height above the 6-inch I-beam supports. Drainage area 57.7 square miles. Cost of unit $775, materials $266, labor $100, wire $8, line and building wiring done under code regulations $80, total $1,229. Estimated cost of current per year, $152

Sometimes considerable money is spent, and only a small amount of power is obtained. In some instances plants have been partly built and equipped, and then power has been taken from a near-by commercial line. Figure 11 shows a plant in Pennsylvania which cost about $1,800 and was intended to supply current for two farms. Owing, however, to the small and variable discharges from the drainage area of 1.3 square miles, the lack of water storage, and the increasing need for current, use of the electrical equipment was discontinued and power was taken from a commercial line. The plant has a 7½ by 2 foot steel overshot wheel which, when the installation was inspected, was using 12 cubic feet of water per minute. This gave ample power for the operation of a very satisfactory domestic water system. The pump discharge was piped to the tops of two 10-room farm houses and thence to the barns and yards where watering troughs received the surplus. There were no storage tanks, and as the pump was run night and day the water was always cool and wholesome.

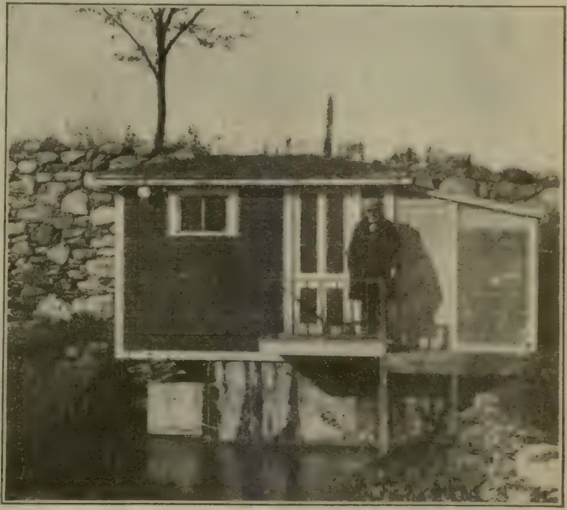

FIGURE 5.—Compact turbine plant in Massachusetts, built over the tailrace of an old rubble-face earth dam 18 feet wide on top (at tree). Drainage area 8 square miles, head 10 feet. Plant supplied current for lighting five rural houses

USE AND CARE OF PLANTS

Plants are generally run continuously. If electricity is generated, it is common practice to use the current for power during the day so as to have a better flow of current for lighting at night. Most owners burn yard or porch lamps throughout the night, and in cold weather some switch on a small electric heater. In addition to lamps the electric appliances in most common use are irons, vacuum cleaners, washing machines, pumps, refrigerators, and one or more small motors for miscellaneous use. Generators are direct-current machines and generally have a full-load voltage rating of 110 to 125.

Farm water-power plants require attention and repair, and while those items do not involve much expense they can not be ignored. Some owners visit their plants daily, some every other day, and others weekly. If the visit is merely for inspection or to oil or grease bearings it may not take more than 20 to 40 minutes, depending upon the distance. If ice or leaves interfere with wheel operation the visits must be more frequent. The cost of oil, grease, and repairs at one plant (fig. 7) was $13.27 in 1925, $5 in 1926, and $59.80 in 1927.

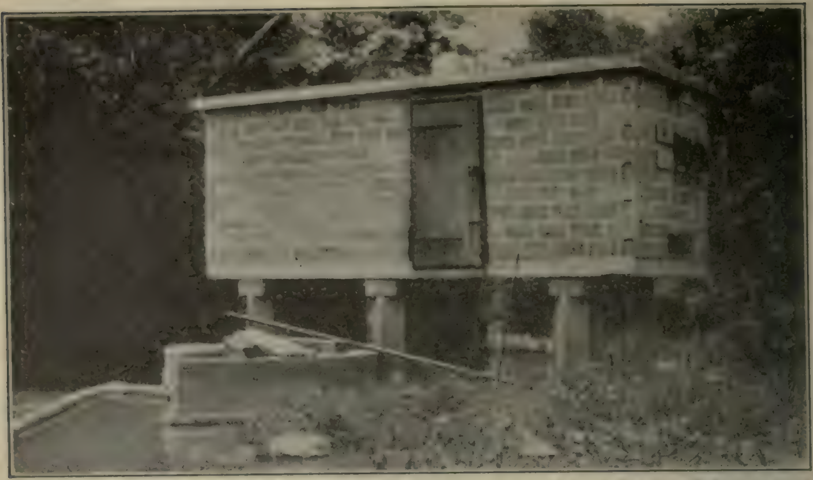

FIGURE 6.—Upstream side of a substantial concrete power house 7.7 by 20 feet, 6-inch roof slab, 8-inch block walls, 8-inch floor slab, supported above high water by three piers 17 inches thick built into and buttressing a concrete dam 129 feet long. Drainage area 43.9 square miles, head 7.7 feet. Cost of 24-inch turbine $310, 6½-kilowatt generator $400, materials $1,185, labor $750, wire $422, instruments and miscellaneous $385, total $3,452. Approximately one-half the cost was for the dam. Estimated cost of current per year, $469

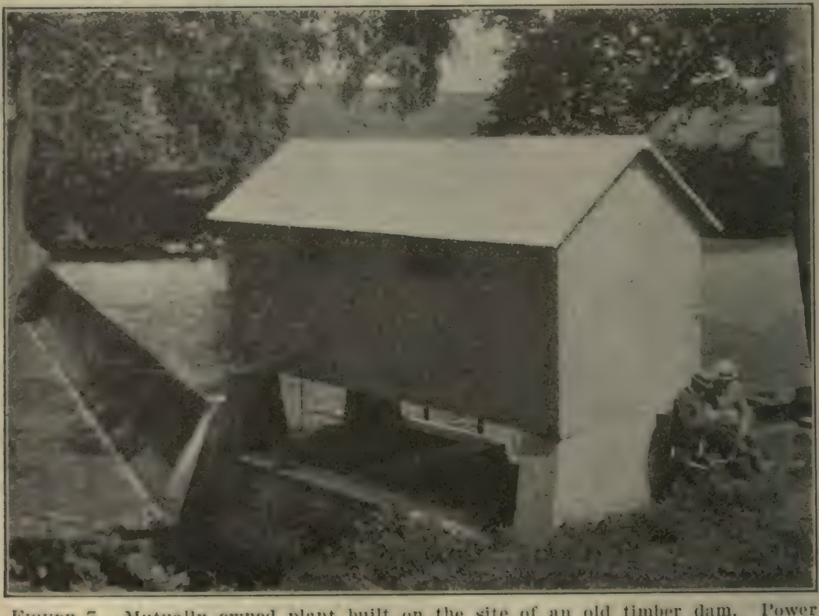

FIGURE 7.—Mutually owned plant built on the site of an old timber dam. Power house 8.6 by 20 feet, concrete dam 141 feet long, drainage area 51 square miles, head 7.5 feet. Cost of 27-inch turbine $393, 6-kilowatt generator $550, governor $460, materials $1,582, labor $1,000, wire $632, rent and supplies $250, instruments and miscellaneous $821, total $5,688. Approximately two-thirds of the cost was for the dam. Estimated cost of current per year, $754

PLANT DESIGN

Every farm water-power project calls for careful study. The power must be used as and when generated. It is true that surplus current is sometimes used to charge storage batteries for lighting purposes, but most farmers wish to avoid the purchase of large storage batteries because of their cost and comparatively short life. The hope of securing continuous power without the bother of storage batteries has been the main reason why many have undertaken development of water power. Owners frequently like to experiment, often using second-hand equipment and parts—a wheel bought here, and a shaft bought there. Although such experimentation is interesting and worthwhile results sometimes follow, it is generally better and cheaper to obtain the advice of men experienced in the design and installation of water-power equipment.

WATER SUPPLY

The area of a drainage basin is only a partial index of the quantity and constancy of the discharge. But assuming similar relief and rainfall, the discharge from a large area is likely to be greater and more uniform than that from a small area. The run-off from some small areas is augmented by springs or seeps, and the discharge is well-sustained during droughts. In general, however, discharge fluctuates greatly with rainfall, and as rainfall usually runs from a small area quicker than from a large area, the former is likely to have the more varied and higher run-off per unit of area. The discharge from a typical hilly to mountainous drainage area of 22 square miles in New York during a year of nearly normal rainfall is summarized as follows: Maximum discharge, 30,120 cubic feet per minute on May 12; minimum discharge, 35.4 cubic feet per minute on October 21; mean daily discharge for the month of least run-off (October), 53 cubic feet per minute; mean daily discharge for the month (June) having the sixth smallest average, sometimes called the sixth driest, 529 cubic feet per minute; mean daily discharge for the year, 1,512 cubic feet per minute; number of days when the mean discharge was between 35.4 and 504 cubic feet per minute, 183 (one-half the time).

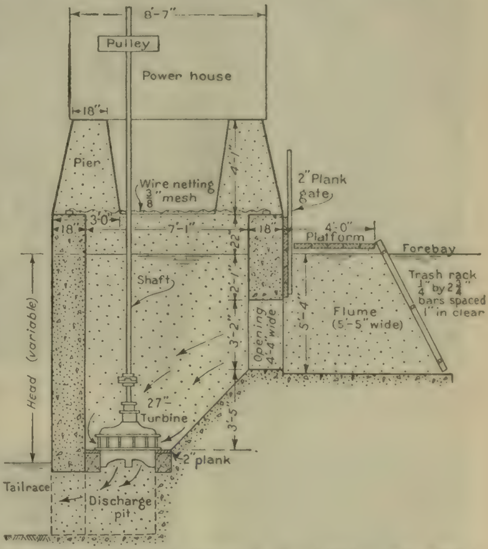

FIGURE 8.—Section through the turbine pit, flume, and trash rack of the plant shown in Figure 7. The wire netting which completely covers the pit is for the purpose of excluding débris at times of high water

Very different discharges might occur another year or from a like area in another locality during the year considered. The figures emphasize the importance of obtaining as full information as pos-

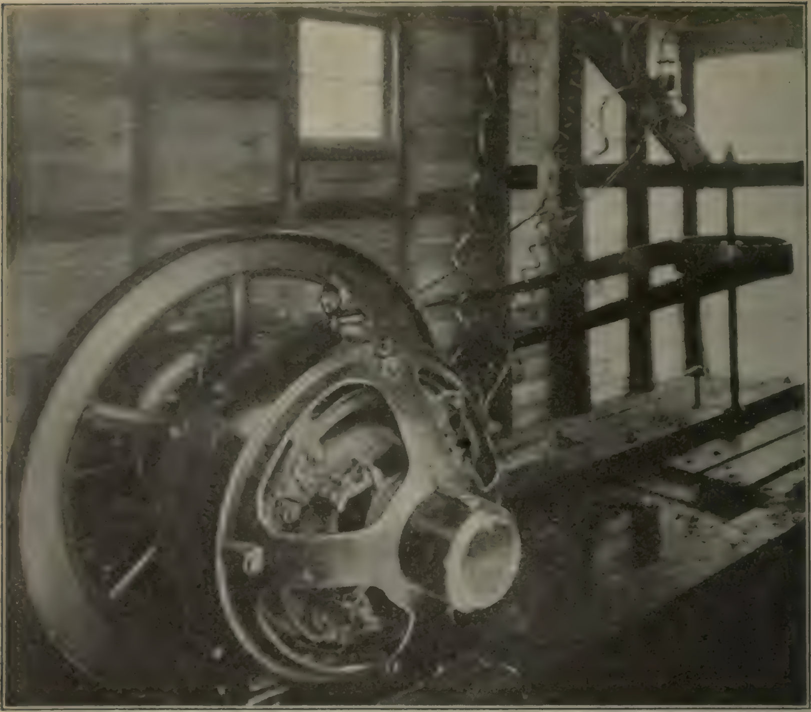

FIGURE 9.—Quarter-twist belt drive from a 26 by 6 inch pulley on the vertical shaft of a 15-inch turbine to a smaller pulley on the generator

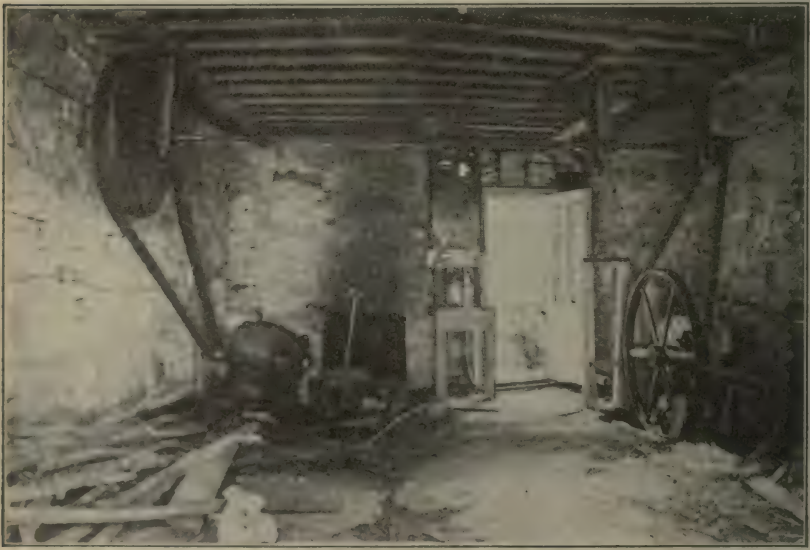

FIGURE 10.—Stepping up the speed of a 10 by 3 foot steel overshot wheel in New Jersey. The large sprocket wheel at the right is keyed to the axle of the water wheel outside the wall and is connected by chain drive with a small sprocket wheel on the overhead line shaft, which in turn is belted to a 7-kilowatt generator at the left

sible regarding the flow of a stream upon which power is to be developed. They also show that the occasional high discharges for brief periods, while swelling the figures for mean discharge, are worth little for power purposes unless there is liberal provision for storing a part of the flow.

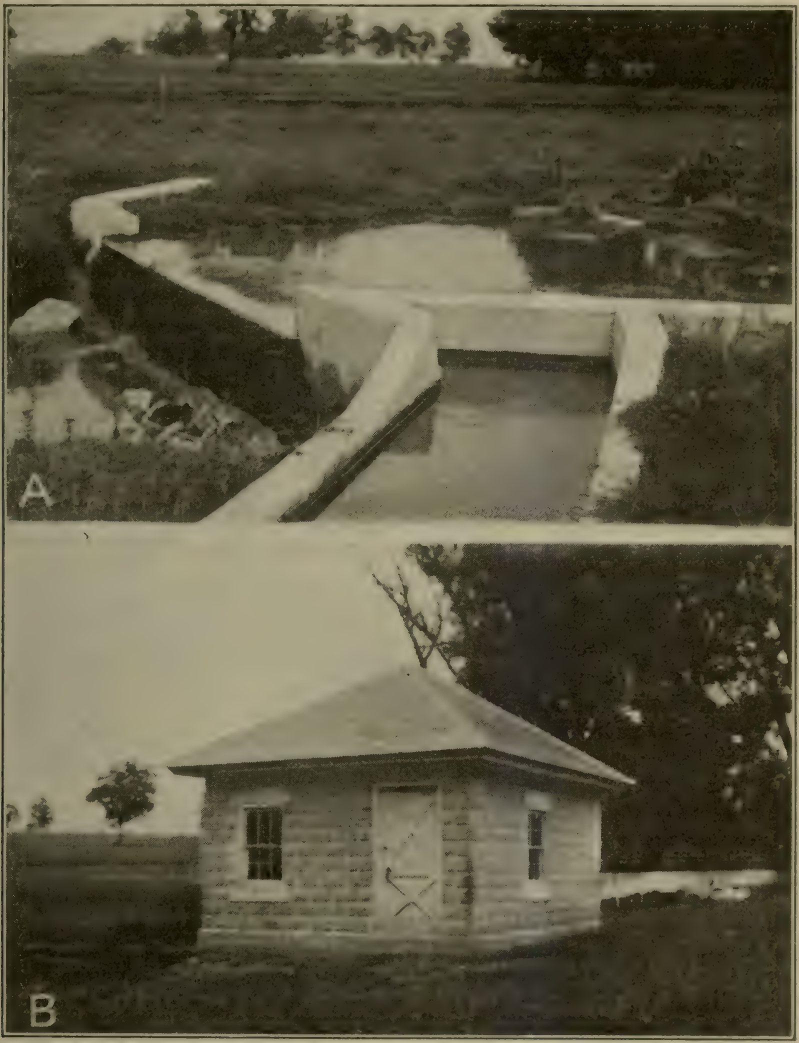

FIGURE 11.—Attractive, substantial plant in Pennsylvania which cost about $1,800 in 1917 and is now used only for driving a 2½ by 4 inch piston pump estimated to discharge 2¼ gallons per minute: A, Concrete diversion dam and entrance to flume 30 inches wide and 17 inches deep inside; B, cement-block power house 14 by 16 feet and concrete flume 225 feet long having a fall of 3½ inches

Decision as to wheel capacity is sometimes based on what may be termed the "middle-time flow" which means that flow, in a year of normal rainfall and run-off, which is exceeded on half of the days in the year and is not equalled on the remaining days. Assuming a wheel capacity equal to this middle-time flow and that there is no storage, waste of water, or variations in head, the result to be expected from an ordinary stream is about as follows: (1) A flow capable of driving the wheel to full capacity for 183 days of the year; and (2) an average flow of 50 per cent of the wheel capacity for the remaining 182 days of the year. This is equivalent to an average usable flow of 75 per cent of the wheel capacity for the whole year.

Many believe that the large demand for power comes in the spring when there is likely to be plenty of water. They therefore contend for the selection of a wheel of correspondingly large capacity. However, the principal uses of farm water power are for lighting, operating household appliances, and pumping. These uses call for some power every day, and except for lighting the seasonal variation is usually not large. In every instance consideration should be given to the amount of power needed and to how it is to be used, whether a large amount of power is required for a short time or a small amount of power for a long time.

Middle-time flow is a well-balanced compromise between the two extremes of stream discharge. It should not be confused with mean (average) discharge usually given in published records of stream flow. Mean discharge is usually larger than middle-time discharge and is obtained by summing the daily discharges for a year and dividing the sum by 365. Wheel capacity is sometimes based on the average daily stream discharge during that month having the sixth smallest average. This method, however, is less reliable than that based on middle-time flow. Where the flow is well sustained during the dry season or large storage capacity is possible, estimates may be based on a discharge which is nearer the average discharge.

Small discharges can be accurately determined by weir measurements as described in Farmers' Bulletin 1683, Measuring Water in Irrigation Channels. However, this method is not always convenient, nor are a few refined determinations as valuable for the purpose as are a large number of fairly accurate determinations covering daily discharges for one or more years. Large discharges are best determined by a competent hydraulic engineer, but a farmer can easily and quickly determine the approximate flow in the following manner: First, find the velocity of flow of the stream, and then, find the cross-sectional area of flow. The product of the two gives the rate of discharge at the time and place of making the test. These steps are explained as follows:

(1) Measure 50 to 100 feet along the bank of the stream where the bed is smooth, and of uniform width and depth. When there is no wind throw a chip of wood into the middle of the stream above the upstream point of measurement and note the exact number of seconds required for it to pass the measured distance. This can be done most accurately by the use of a stopwatch costing about $5. If the stream can be waded or is spanned by a low bridge, a still simpler 1-man method of making float tests is to attach one end of a measured length of ordinary fish line to a float and note the time required for it to move from the observer's position to the end of the line when fully payed out. As the midstream flow is usually swifter than that nearer the banks, make several tests from bank to bank and average the time. Divide the distance in feet by the average time in seconds, and multiply the result by 60 to get the average surface velocity in

feet per minute. As friction against the stream bed retards the flow, deduct 20 per cent (one-fifth) to approximate the average velocity of the entire cross section of flow.

(2) Determine the surface width of the stream and make measurements of the depth of the water at frequent intervals from bank to bank. Multiply the width of the stream in feet by the average depth in feet to get the cross-sectional area in square feet. This area, in a small stream having a round-shaped bed, is roughly two-thirds of the product of the surface width by the middle depth. These measurements must be made at the same time and place as the velocity measurements.

(3) Multiply the cross-sectional area of flow, in square feet, by the average velocity, in feet per minute, to get the discharge in cubic feet per minute.

POWER ESTIMATES

Water power is estimated from the quantity of water flowing and its vertical fall (head) from water surface to water surface at two points on the stream. The available power is frequently overestimated because of lack of water in dry times, unusable water in wet times, and loss of head in overcoming resistance to flow in the channel leading to and from the wheel. Wheels and generators of large capacity do not necessarily give a large amount of power. Unless there is sufficient water and head to drive the machinery at or near its rated speed it will not develop its greatest efficiency or power, and neither the operation nor the economy will be so satisfactory as could be obtained with smaller and less costly equipment run and loaded close to the manufacturer's rating. It is very important to distinguish between net or effective head referred to in manufacturer's power and speed tables, and total head as usually measured in the field. Effective head is the actual head at and on a wheel when running. Manufacturers in referring to head mean effective head, assuming full or nearly full gate opening and a well-installed wheel in good operating condition.

To find the total head, take the difference in level between the water surfaces at the proposed intake and outlet. The total head at a dam is the difference in level between the upper water surface and the surface at the lower end of the tail water. For short distances this difference may be determined with a carpenter's level or a farm level, but if the distance is more than 200 feet the head should generally be determined by an engineer or surveyor.

To estimate the theoretical or water horsepower, multiply the discharge (cubic feet per minute) by the total head (feet) and divide the product by 528. Example: What is the water horsepower of a flow of 264 cubic feet per minute having a total head of 8 feet? Solution: 264 multiplied by 8 equals 2,112; 2,112 divided by 528 equals 4 water horsepower. Dividing by 708 instead of by 528 will give the equivalent power in kilowatts. All of this power could not be realized because of unavoidable loss of head in waterways and frictional loss in machinery. In making preliminary estimates of farm water power it is unwise to assume that more than 50 per cent of the theoretical power will be realized at the switchboard. Thus under the conditions in the example about 2 horsepower or 1½ kilowatts would be available.

DAMS AND STORAGE

A dam serves two purposes: (1) To create head; and (2) to provide a storage basin for balancing irregularities of stream flow and increasing power possibilities. A discharge giving 2 horsepower continuously for 24 hours might, if stored and used in 12 hours, permit the use of a 4-horsepower wheel; if used in 6 hours, an 8-horsepower wheel. Farm dams seldom store much wet-weather flow because of the large cost of dams and the lack of flowage rights or difficulty in obtaining them. Continuous operation of a wheel at full capacity frequently exhausts a pond much quicker than anticipated. For example, a turbine using 725 cubic feet per minute would, in a 12-hour run, reduce the head of a 6-acre pond 2 feet if no inflow occurred. An old plant at South Troy, N. Y., illustrates the value of storage. One of the world's largest overshot wheels, 60 by 20 feet, was successfully operated from 1851 to 1897 on the yield of a hilly to mountainous watershed approximately 12 miles long, 3 miles wide, and containing 33.9 square miles. Within this area there are 11 lakes which furnished storage. The wheel normally made two revolutions per minute and required 4,500 cubic feet of water.

Figure 12 shows cross sections at the spillways of typical farm dams. Some of the sections could have been improved without adding to the cost of the dams, but each is probably strong enough for its location and intended purpose. Few of the spillway openings are sufficiently large to pass freshets. In the smaller dams the crest of the spillway generally was one-half to 1 foot lower than the top of the wings; in the larger dams the corresponding depth was 1 to 2 feet. Considerable leakage was observed at certain dams founded on rock; this might have been due to faulty bonding between the dam and rock or to failure to grout the seams beneath the foundation. A common fault is making wings too short at the land end. Unless both wings of a dam are built well into the earth or rock there is very likely to be a leakage around or beneath the ends and damage or destruction by undermining.

Farm dams are generally made of concrete mixed in the approximate proportion of 1 of cement to 6 of sand and stone combined, and reinforced with old steel pipe, rails, structural shapes, or scrap iron. Bankrun gravel was used in some of the dams inspected, but the concrete appeared to be oversanded and therefore of poor quality. Directions for making good concrete are contained in Farmers' Bulletins 1279 Plain Concrete for Farm Use, and 1480 Small Concrete Construction on the Farm.

In many of the States the design and construction of dams is regulated by law. Power of approval is vested variously in a department, commission, board, or State engineer. Different States have different requirements; for example, one State exempts dams where the drainage area is less than one-half square mile and the water is raised less than 5 feet above low water. Wherever State or other laws or regulations govern, the farmer should study these and build his dam to conform to them. The services of an experienced and reliable engineer are recommended as being most likely to result in obtaining a lawful and dependable dam.

CHOICE OF WHEELS

When working at full capacity and under favorable conditions there is no great difference, so far as efficiency is concerned, between

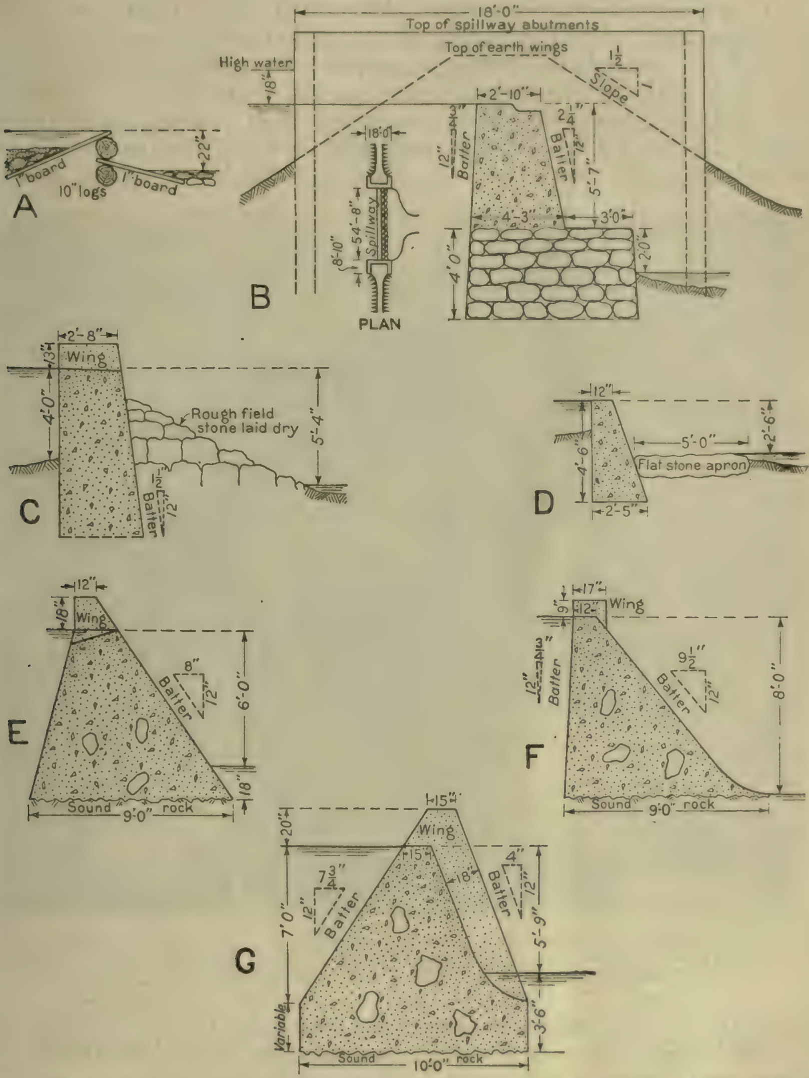

FIGURE 12.—Cross sections at the spillways of typical farm dams: A, Simple log and board dam for diverting a small flow into a headrace. B, Old earth milldam 335 feet long and having a concrete and rubble spillway 54 feet 8 inches long; the original spillway, 36 feet long, was too small and part of the dam was washed away. C, Dam shown in Figure 3. D, Simple concrete diversion dam with stone apron to prevent undermining by the overflow. E, Concrete dam 125 feet long founded on rock. F, Dam shown in Figure 6. G, Dam shown in Figure 7

overshot, turbine, and impulse wheels. Each should develop, at the wheel axle, 75 to 90 per cent of the water horsepower.

Overshot wheels are adapted to small or moderate discharges under effective heads of 5 to 20 or more feet. They are simple, accessible, not easily clogged, and efficient under varying flow; their weight makes for steadiness of motion with load changes. They should never wade in the tail-water, and their slow speed usually requires stepping up, by means of gears and belts, 50 to 150 times to adapt them to electric service. (Fig. 10.) They occupy considerable space and in cold climates should be housed. Very small overshot wheels have little leverage and power. No wheel will do its best work if the water merely drops on the top as shown in Figures 1, 2, and 13. They should be equipped with a tank, as shown in Figure 14, in which there is sufficient head (usually 14 or more inches) over the center of the gate opening to give the water a spouting velocity approximately the same as the velocity of the tips of the buckets. If there is no tank the water lags behind the wheel, and power is lost.

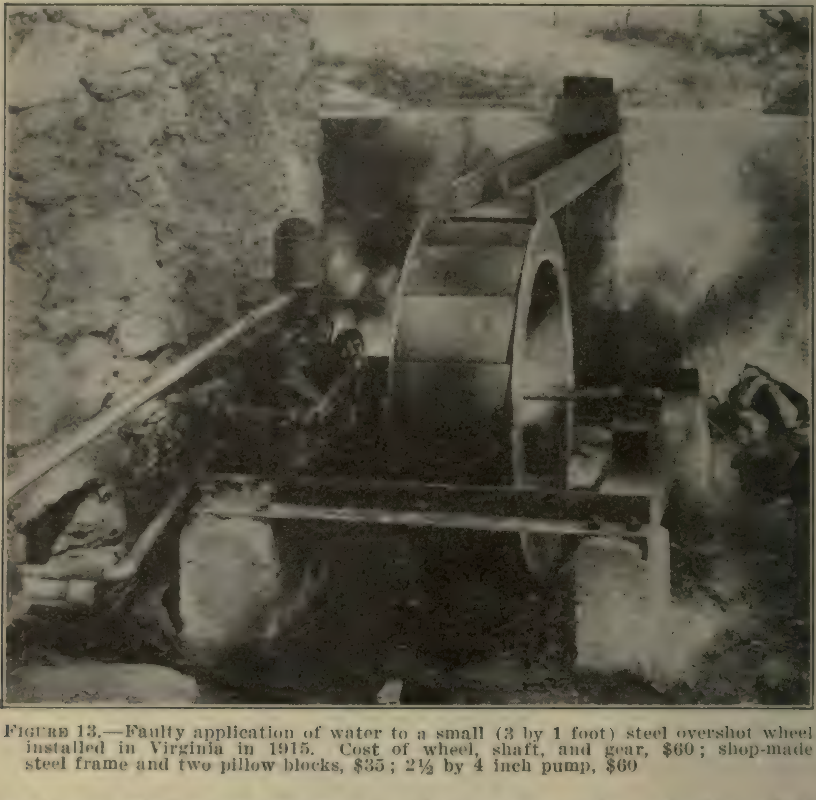

FIGURE 13.—Faulty application of water to a small (3 by 1 foot) steel overshot wheel installed in Virginia in 1915. Cost of wheel, shaft, and gear, $60; shop-made steel frame and two pillow blocks, $35; 2½ by 4 inch pump, $60

Turbines are adapted to moderate or large discharges under effective heads from 4 feet upward. They are quiet, compact, and speedy and will run as long as water covers the turbine case and is higher than the tail-water, but with diminishing power as the head is lowered. Types and characteristics of turbines vary to meet the conditions and requirements. Each turbine does its best work when operating under specific conditions, being designed for a certain head, speed, and quantity of water. The power developed is approximately proportional to the quantity of used water, and that varies with the amount of gate opening. At half or quarter gate opening both the discharge and power are reduced in approximately like ratio from that at full gate. The speed at the turbine plants inspected was usually stepped up three to five times for electric service. (Fig. 9.)

Small, self-contained turbine electric units with automatic governor, and suitable for effective heads of 6 to 20 or more feet, are available. According to one manufacturer's catalogue ratings, a ¼-kilowatt unit having a 6-inch runner under a 7-foot effective head and using 64 cubic feet of water per minute (8 gallons per second) would have an over-all efficiency of 40 per cent. A 10-kilowatt unit having a 12-inch runner under a 21-foot effective head and using 539 cubic feet of water per minute (67.2 gallons per second) would have an over-all efficiency of 63 per cent. Units of sizes between these have intermediate efficiencies. According to the catalogue ratings of another manufacturer, a 1-kilowatt unit costing $600 without governor, having a ball-bearing runner under an effective head of 10 feet and using 100 cubic feet of water per minute (12½ gallons per second) would make 520 revolutions per minute and would have an over-all efficiency of 71 per cent; a similar 10-kilowatt unit costing about $900, under an effective head of 50 feet and using 221 cubic feet of water per minute (27.6 gallons per second) would make 1,165 revolutions per minute and would have an over-all efficiency of 64 per cent.

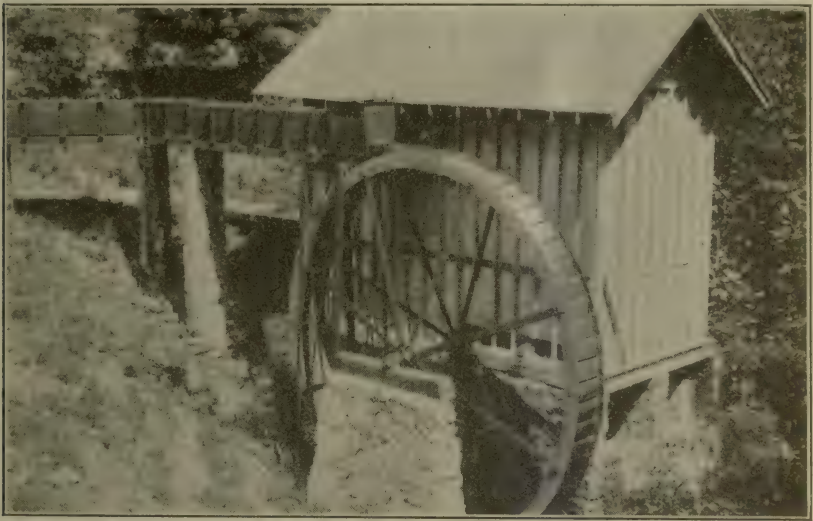

FIGURE 14.—Effective application of water to a 20 by 2 foot steel overshot wheel in North Carolina. Head in the open-top steel tank (2 by 3 by 2¾ feet deep) shoots the water through the gate opening (at bottom of right end) and down a 3-foot long inclined and tapered chute (trough), the lower end of which just clears the tips of the buckets approximately 10 inches short of a vertical line through the center of the wheel axle. The open flume to the tank is made of 1-inch boards lined with galvanized sheets and is 1½ feet wide (inside), 2 feet deep, and 82 feet long, graded to fall 2½ inches. It is supported by two 3 by 6 inch stringers on rubble piers 8 to 10 feet apart

Turbines of the propeller type are a comparatively late development in farm hydroelectric practice. As at present manufactured, they are adapted to medium or large discharges under effective heads of from 8 to 25 feet. However, the normal head at one plant (fig. 4) was only 4 feet. These turbines are small, quiet, and speedy, and are direct connected to the generator. The arrangement of the machinery in a typical unit is clearly shown in Figure 15. This unit is made in four stock sizes having capacities of one-half, 1, 3, and 5 kilowatts. According to the manufacturer's catalogue ratings a 1-kilowatt unit having a 12-inch inlet pipe, a 9-inch runner under an 8-foot head, and using 215 cubic feet of water per minute would have an over-all efficiency of 41 per cent; under a 14-foot head the rating is 120 cubic feet per minute. Another unit having no governor is shown in Figure 16. It has a capacity of 1 to 2½ kilowatts, varying with the head, and is equipped with an inlet valve controlled either by hand or by a distant pushbutton, and a switchboard with voltmeter, ammeter, rheostats, line switch, and fuses. The shipping weight of the unit is about 1,100 pounds, and the cost at the shop is approximately $750 which includes no switchboard wiring.

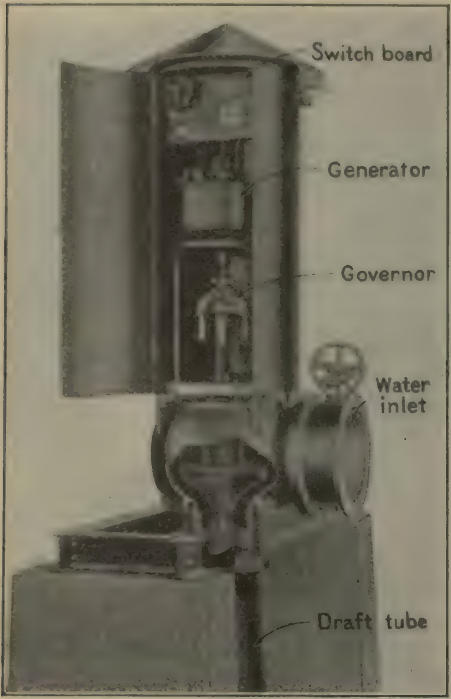

FIGURE 15.—Cut-away view of a power unit comprising a propeller-type turbine, generator, and governor connected to one vertical shaft

Impulse wheels are adapted to small, medium, or large discharges under effective heads from 20 feet upward. They are small, quiet, and speedy and are especially suitable for high heads where water can be delivered to the wheel by a comparatively small pipe. Figure 17 shows a power unit adapted to effective heads of 46 to 230 feet. It is made in four sizes varying in capacity from 150 watts to 20 kilowatts, in weight from 250 to 2,600 pounds, in floor space from 2 by 2½ feet to 3½ by 4½ feet, and in cost from $315 to $1,800. According to the manufacturer's rating, a typical unit adapted to 80 feet of effective head and costing $475 would use 13.2 cubic feet of water per minute (1.65 gallons per second), develop 1 kilowatt, and have an approximate over-all efficiency of 66 per cent.

Figure 18 shows two 3⅓ by 2⅓ foot steel pitch-back wheels for pumping water. A small underground flume at the far side of the pits delivers water to the buckets several inches below the tops of the wheels.

Figure 19 shows a $30 homemade pumping plant which, under continuous operation for 3 years, furnished an Alabama family with spring water at a cost of 75 cents for repairs.

Figure 20 shows a 5 by 3 foot undershot wheel for pumping water. Wheels of this kind do not develop much power and cost approximately 25 per cent more than overshot wheels.

HEADRACE AND TAILRACE

Most farm water powers are operated under small or moderate head, and it is very important to reduce the head losses as much as possible. These losses, including those in the wheel pit and tailrace which often are excavated with difficulty and subject to cave-ins and neglect, frequently are 20 to 30 per cent of the total head. A headrace or flume should be sufficiently large and clear to deliver at slow velocity the maximum quantity of water required at the wheel. A mean velocity in earth or rock channels of from 60 to 75 feet per minute (1 to 1¼ feet per second) is generally desirable. This velocity will ordinarily be approximated if headrace and tailrace are graded to fall 1 inch in 100 feet. The reader should bear in mind that velocity of flow is affected, not only by the amount of fall but

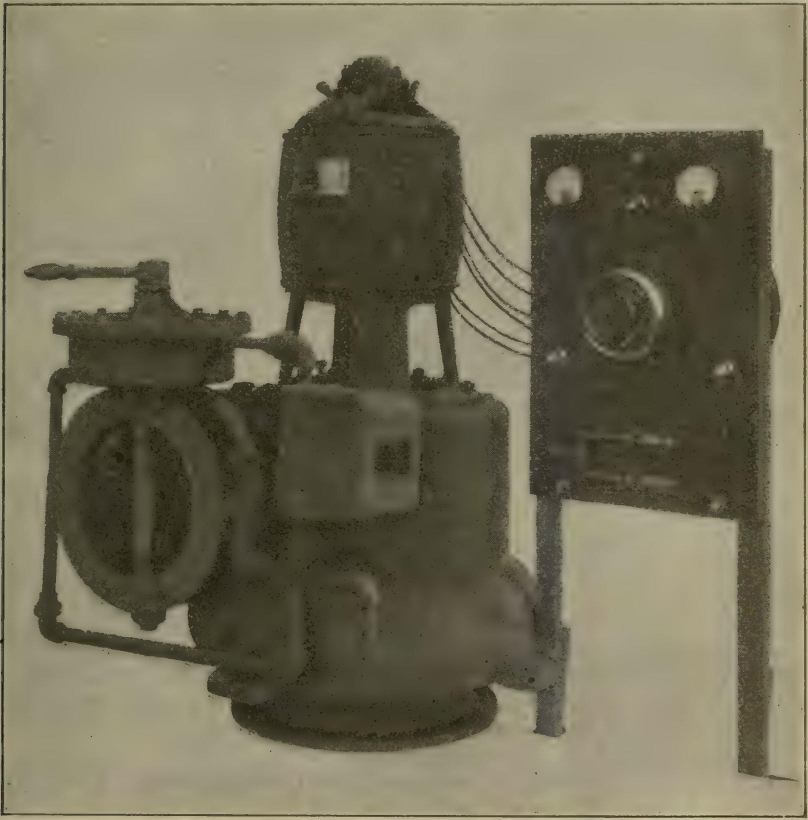

FIGURE 16.—A power unit comprising a vertical-shaft, propeller-type turbine and a generator and equipped with both hand and electrical control

also by the size of channel and quantity of flow, small canals or ditches requiring greater fall than large ones in order to produce a given velocity.

On the basis above outlined determination of the size of a canal at and below the flow line is a simple matter. Example: Assuming a mean velocity of 75 feet a minute, what size of canal is required for a turbine having a rated capacity of 600 cubic feet per minute? Solution: 600 divided by 75 equals 8, which is the cross-sectional area of flow in square feet. The most effective cross section would be half circular or U shaped with the width twice the depth. A canal of suitable dimensions, then, would be a half circle with a radius of 2 feet 3 inches, or a U shape of 4 feet average width by 2 feet average depth. Either section would have the required area of 8 square feet. The flow in most farm canals is much shallower than above indicated, but shoal sides favor the formation of ice and retard flow, grass and weeds take root, and débris collects. It is important to make canals deep and to keep them clear. Directions for ditching with plows and with dynamite are given in Farmers' Bulletin 1606, Farm Drainage. A velocity of 120 to 300 feet per minute (2 to 5 feet per second) is permissible in a short smooth pipe, flume, or penstock.

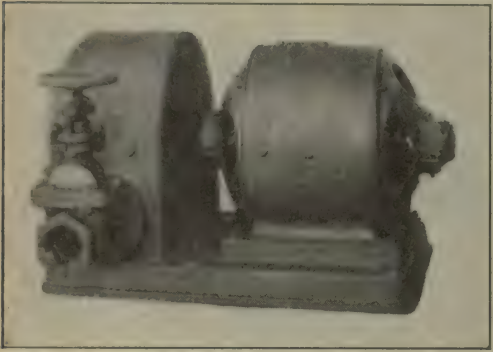

FIGURE 17.—A compact unit, comprising an overhung metal-housed impulse wheel direct-connected to a generator

A wheel pit should be the full depth and width recommended by the manufacturer of the wheel to be installed, and the wheel when running should be entirely clear of the tail-water. Even slight wading results in large loss of power. The draft tube of a turbine should extend at least 3 or 4 inches into dead water in the tailrace. The bottom of a tailrace should be graded evenly from the bottom of the discharge pit to the bed of the stream at the point of outlet. If so graded and if the tailrace is of ample width, the used water escapes with little surging and rise, and consequent loss of power.

TRASH RACKS

Leaves, twigs, sticks, and pieces of ice are likely to float along the shores of a stream and to be drawn into any open headrace or flume in which there is flow. A trash rack to intercept such matter is necessary in a turbine installation, but one is seldom installed at an overshot wheel. Eels were the principal cause of trouble at a North Carolina plant. The trash rack shown in Figure 8, which has a 1-inch clear spacing of the bars, is a typical one. A ½ to ¾ inch spacing is sometimes employed to strain out as much débris as possible. Whatever the spacing, care should be taken to have a large total area of opening so that flow shall not be much impeded and head lost. There are several ways of gaining area, but the simplest is to have the rack inclined instead of vertical. Inclination also facilitates the use of a rake for the removal of débris which then has a tendency to slide upward.

A garden rake or a manure rake is generally used to clear racks, but the work is much facilitated by using a regular trash rake with deep basket, and guards on the end teeth to prevent hooking under the spacing rods across the rack. In the fall, leaves are the chief cause of trouble and sometimes blanket a rack within an hour or two. An early morning inspection at one plant (fig. 7) showed the rack so matted with leaves that the normal head of 7.5 feet was reduced to 2.7 feet, and the power output was almost negligible.

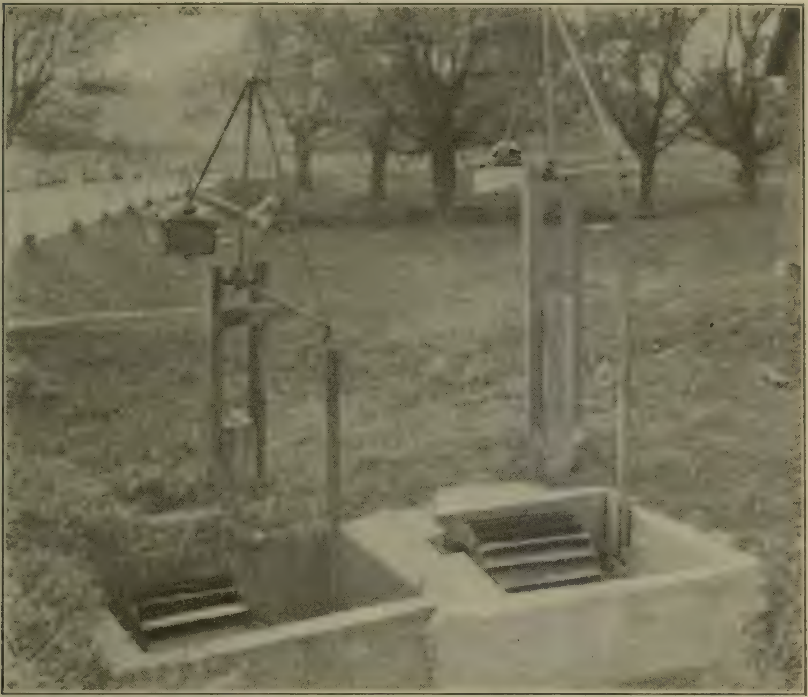

FIGURE 18.—Two pitch-back wheels, in Pennsylvania, which make about six revolutions per minute and are connected by 8-inch cranks (16-inch stroke) to counterweighted steel triangles having draft wires to two pumps about 400 feet away. The left wheel cost $45 at the shop 15 years ago and the right wheel cost $75 recently

GOVERNORS

Few plants have governors to regulate delivery of water according to the load on the wheel. The lack of a governor renders a plant unresponsive to power needs. In the absence of a governor hand control is necessary, and the inconvenience discourages the use of large machines and appliances such as feed grinders, silage cutters, and ranges. Most plants operate on a more or less constant part-gate opening. Therefore the power developed is much below what the wheels are capable of developing. This condition prevails even when there is an abundance of water.

Governors are costly and do not always give the results expected. An automatic, fly-ball governor for a small overshot wheel costs approximately $100; for a medium-sized wheel, about $250. Two governors that were examined—one costing $25 (second-hand) and the other costing $460 were in disuse because of stripped gears or other breakage. It is not certain whether the damage was due to faulty installation of the governors or to some obstruction which prevented closure of the turbine gate when the load was reduced by cutting off electric motors and appliances. The latter cause seems the more probable. A turbine, although protected by a screen or trash rack, may become dirty and clogged, thus interfering with the action of the gate and reducing the discharge and power.

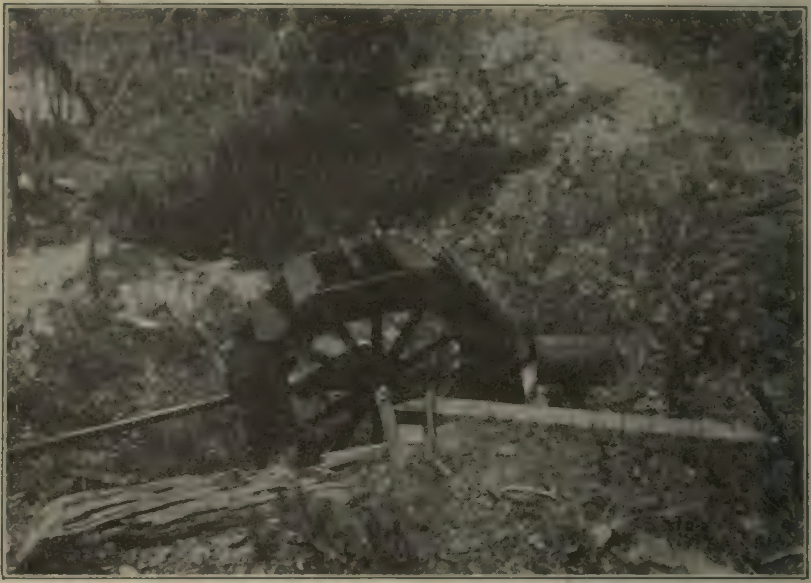

FIGURE 19.—A 3-foot water wheel comprising an old automobile axle and rim to which are bolted wooden buckets roughly 12 inches square and 4 inches deep; a few feet of 5-inch concrete pipe delivers water through a dam to the right side of the wheel, from which a 20-foot connecting rod delivers a little power to a lever-operated pump. (A pipe through a dam should have one or more short masonry cut-off walls or flanges to prevent seepage along its outside surface.)

A governor is a desirable accessory, provided it is properly installed and given the necessary attention.

WIRING

Power-line wires are often too small, resulting in excessive drop in voltage with attendant loss of illumination and slowing and heating of motors. It is strongly recommended that wiring[1] be done only by those duly qualified, and in conformity with the local or State regulations and the National Electrical Code.[2] A fair average charge for complete house wiring, exclusive of fixtures is $10 to $20 per room or $4 to $5 for each light, wall switch or convenience outlet.

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[1] A useful bulletin, Wiring the Farm for Light, Heat, and Power, is published and sold by the Committee on the Relation of Electricity to Agriculture, 1120 Garland Building, Chicago, Ill.

MANUFACTURERS' HELPS

The engineering departments of most manufacturers of water wheels are prepared to advise regarding hydraulic and electrical problems. Blue prints showing the proposed equipment and method of installation are usually furnished. Some manufacturers will send an engineer to investigate and a man to supervise erection and installation. Generally, manufacturers of water wheels and electrical equipment consider it good business policy to do all they can to supply equipment suited to local conditions and to have the equipment correctly installed. They give instruction regarding the erection, operation, and repair of their product. Generator and motor manufacturers furnish wire-connection diagrams and directions regarding the installation, lubrication, operation, and care of those machines, and the renewal of parts. Belt manufacturers advise regarding the choice, care, and repair of belts, and the size and spacing of pulleys. Information on belts and their care is given in the Department of Agriculture Yearbook, for 1928, p. 151–154.

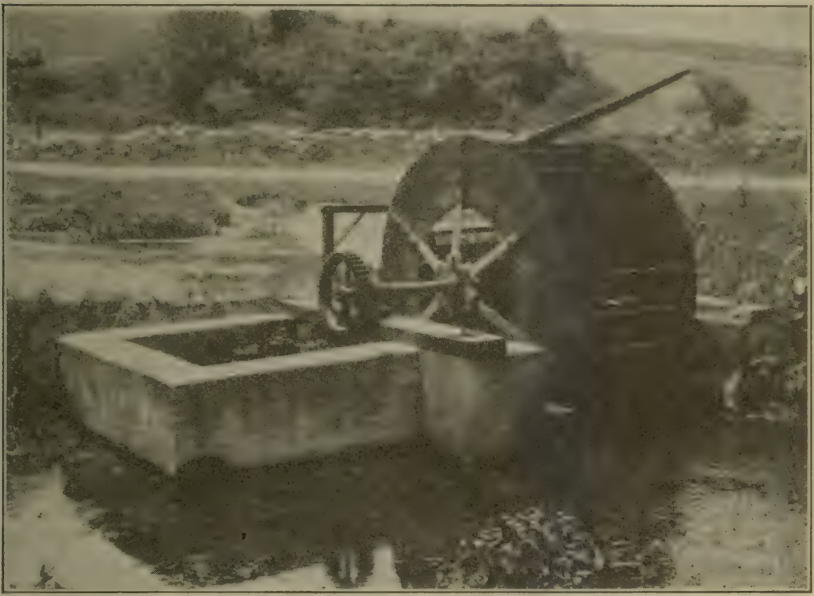

FIGURE 20.—Downstream side of a 5 by 3 foot undershot wheel geared to a 2½ by 4 inch triplex pump. The machinery cost $205 in 1914. Pennsylvania

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[2] Persons having real use for the code may obtain copies from the National Fire Protection Association, 60 Batterymarch Street, Boston, Mass., or the National Board of Fire Underwriters, 85 John Street, New York City.

DEPARTMENT HELPS

Requests to the department for advice as to proposed water power developments seldom are accompanied by information sufficient to make possible a satisfactory reply. Correspondents often state that there is water enough to fill an 8 or 10 inch pipe or that there is a lively creek 6 or 8 feet wide and a foot deep. Such information is worthless for estimating power unless the velocity of the water and other field data are also given. The department is not in a position to prepare designs, plans, specifications, or estimates of costs, but will give an opinion as to the probable value of a proposed development. Those asking for advice should supply as much as possible of the information outlined below:

(1) Name of stream and location of dam in such detail that it can be located closely on Government or State maps.

(2) Can use be made of an existing dam, headrace, tailrace, power house, wheel, or storage battery? If so, which?

(3) Minimum flow and middle-time flow of stream in cubic feet per minute. (P. 7 to 10.)

(4) Natural fall of the stream at the power site and the total fall it is feasible to obtain by constructing a dam. (P. 12.)

(5) Kind of dam, length, average height above the stream bed, and character of the foundation.

(6) Will water be conveyed to the wheel by a ditch, flume, or pipe? Give its length in feet.

(7) If the plant is for electric service give the distance from the power house to the farm buildings.

(8) What is the least amount of power (total watts required for appliances in actual use at one time) that will give satisfactory service? The requirements of some appliances, at full capacities and average efficiencies, are approximately as follows: Lamps of average capacity, 40 watts each; coffee percolator, 400 watts; bread toaster, 500 watts; 6-pound flatiron, 550 watts; ¼-horsepower motor, 288 watts; ½-horsepower motor, 518 watts; ¾-horsepower motor, 746 watts; 1-horsepower motor, 966 watts. Example: Six 40-watt lamps and a ¾-horsepower motor at full load would require 986 watts.

(9) If not for electric service, state fully the kind and size of machinery to be driven.

(10) Submit a pencil sketch clearly showing the location of buildings, ordinary and high water shore lines, dam, and power plant.

U.S. GOVERNMENT PRINTING OFFICE: 1933

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1659

OATS in the NORTHEASTERN STATES

1862 1889

OATS HAVE BEEN GROWN in the Northeastern States since early colonial days. To-day they constitute the third most important cereal crop of the area, occupying approximately 3,000,000 acres annually. Oats have maintained an important place in the agriculture of this region in spite of their comparatively low acre value (1) because they fit so well into existing rotations and (2) because of their value as feed for work stock and dairy animals. The use of improved cultural methods and varieties should increase acre yields and therefore make the crop relatively more satisfactory.

The requirements for growing oats successfully in the Northeastern States are:

A well-prepared seed bed on fairly productive land.

The rational use of farm manures and commercial fertilizers in producing the crop.

Growing oats in a rotation with legumes and row crops.

Clean, viable seed of adapted high-yielding varieties treated for smut.

Early seeding, preferably with a grain drill.

Harvesting the crop at the best time for yield and quality.

Protecting grain and straw from the elements by attention to details in shocking, stacking, and storage.

Careful threshing.

Directions for making the production of oats more profitable in the Northeastern States are given in the following pages.

This bulletin supersedes in part Farmers' Bulletin 892, Spring Oat Production.

Washington, D. C. **Issued March, 1931**

OATS IN THE NORTHEASTERN STATES

By T. R. STANTON, *Senior Agronomist*, and F. A. COFFMAN, *Associate Agronomist, Office of Cereal Crops and Diseases, Bureau of Plant Industry*

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IMPORTANCE OF THE CROP

OATS HAVE BEEN GROWN in the Eastern and Northeastern States since early colonial days. In States like New York and Pennsylvania, oats constitute the third most important cereal crop, being exceeded in grain production only by corn and wheat. Approximately 3,000,000 acres of oats are grown annually in the northeastern oat area. As is true in other regions, oats are not very profitable in actual cash returns. Nevertheless, they fit so well into existing rotations and are such a valuable feed for horses, dairy cows, young stock, and poultry that the crop occupies an important place in the agriculture of this region. The average acre yield for this region is approximately the same as that for the entire United States. Owing to a relatively smaller acreage per farm, the more general use of improved cultural methods and varieties should result in producing more and better oats per acre. The northeastern and other oat areas in the United States are shown in Figure 1.

SOILS FOR OATS

Some of the soils of this area have been cultivated for more than two centuries. However, with proper handling and rational fertilization they still are capable of producing excellent yields of oats and other crops. Frequently in oat production, proper climatic and cultural conditions are more important than the character or even the fertility of the soil. Because of their greater water-holding capacity, clay and loam soils are better than sandy soils for oats. Sandy soils that have been well supplied with plant food and have a subsoil of moderately fine texture will produce satisfactory crops of oats. The heavier, undrained clay soils occurring in some sections of this area frequently are too wet and cold for the best growth of the oat plant. The heavy clay loams, which are quite common in this area, are well adapted to oats. Land that naturally retains moisture or that is well filled with humus should be used, as oats have a high water requirement. Oats lodge easily and should not be grown on very rich or on low, undrained land. Oats grown on poorly drained, wet soils may be injured by plant diseases, especially rusts, mildew, etc. The crop usually does well on the well-tilled soils of the less hilly sections of Pennsylvania and New York, such as that shown on the title-page and in Figure 2.

FERTILIZERS AND MANURES

Although oats respond well to liberal fertilization, it usually is more profitable to apply fertilizers to other crops in the rotation. Under some conditions, however, it may be profitable to apply fertilizers directly to the oat crop. Ordinarily in this area oats do not suffer because of too great a supply of nitrogen, as is true on the more productive soils of the Corn Belt.

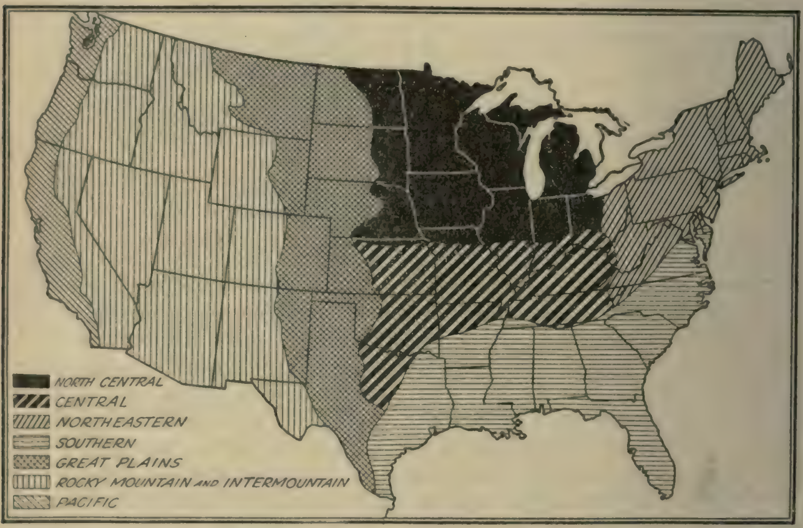

FIGURE 1.—Outline map showing the northeastern and other oat areas of the United States

Unless the soil is exceedingly low in fertility, the direct application of barnyard manure to oats is rarely advisable. Usually more satisfactory results are obtained by applying manure to some other crop in the rotation, such as corn or potatoes, than by making application directly to the oats. The oats then will profit by the residual effect of the manure and the added humus in the soil and will be less likely to produce a rank growth of straw which may lodge and thus reduce grain production. It will be safe to apply well-rotted stable manure at the rate of 10 to 15 tons per acre on the poorer soils of this general region a few months previous to sowing the oats. The use of some phosphate with manure usually is advisable. As a rule, superphosphate is more profitable than rock phosphate to supplement manure.

These old soils usually are deficient in one or all of the three most important plant nutrients; that is, nitrogen, phosphorus, or potassium (potash). These must be replenished for satisfactory crop production. Phosphorus is more frequently not present in sufficient quantities for the satisfactory production of oats. Most soils in the Eastern and Northeastern States are deficient in phosphorus, and it must be supplied by the application of manure or commercial fertilizer.

Small quantities of nitrogen or nitrogenous fertilizer can be used on the oat crop to advantage, especially where neither stable manure nor green manure is available. Where nitrogen in commercial form is applied to oats at seeding time it is better to use some readily available form, since soil nitrogen ordinarily does not become available until later in the season. Potash ordinarily can be applied more profitably to some other crop in the rotation, such as corn or wheat. This plant nutrient usually is present in sufficient quantities in clay soils. However, in the more gravelly and sandy soils of this region there frequently is a deficiency of potash, in which case it should be supplied in some commercial form.

FIGURE 2.—A field of excellent oats about ready for harvest near Sunbury, Pa.

Frequently a complete fertilizer—one containing nitrogen, phosphorus, and potash—is used on the oat crop in this region. A good combination on average soils is one containing from 50 to 100 pounds of nitrate of soda, 200 to 250 pounds of superphosphate (acid phosphate), and 40 to 80 pounds of muriate or other potash salts, applied 200 to 300 pounds to the acre. On the heavier loam and clay soils potash may be omitted. On farms where some barnyard manure is available the best results with oats ordinarily are obtained by applying 200 to 250 pounds of superphosphate. In any region where the nitrogen and potash content of the soil is taken care of by proper crop rotation and good cultural methods the application of 150 to 200 pounds of superphosphate usually is one of the most satisfactory fertilizer treatments for oats. Where oats are being grown on land fairly high in nitrogen the straw may be stiffened by the use of small quantities of potash and phosphorus, preferably in the form of muriate of potash and superphosphate, respectively. Under any condition the quantity of fertilizer to be applied and the proportion of the different fertilizer elements to be used depend primarily on the nature and fertility of the soil and the local price of fertilizers.

Where oats are desired for forage rather than for grain production, the use of barnyard manure or fertilizers high in nitrogen is sometimes advisable. The nitrogenous fertilizers induce a rank growth of straw which is necessary for the production of large yields of forage.

On very acid soils, or when green-manure crops or stable manure are used, the application of lime may have a beneficial effect on oats. Ordinarily, liming alone will not increase the yield of oats. The function of lime is to correct soil acidity and to improve the physical condition of the soil and thus make it more favorable for the growth of the oat plant. Lime or fertilizers applied to oats may not be directly profitable; yet increased yields obtained from succeeding crops frequently make up the deficiency where clover or grass usually follow oats. This is particularly true in the Northeastern States.

OATS IN THE ROTATION

Any rotation for oats should include both a cultivated and a legume crop. In the Northeastern States oats seldom are sown after grass, as corn or other row crops occupy this place in the rotation to better advantage. Oats are grown here, as elsewhere, mainly because of their value in rotations. No other crop is so satisfactory to follow corn as oats. In much of this area corn matures too late to be followed satisfactorily by winter wheat. As a result, a large acreage of corn-stubble land is sown to oats the following spring with the major purpose of getting the land back to grass, oats being a satisfactory nurse crop for grass and clover in this region. Oats also furnish feed and straw for use on the farm.

The yield of oats also usually is less affected by the preceding crop than are yields of corn, wheat, barley, etc. Owing to this fact, rotations most often are arranged for the benefit of the other major crops rather than for oats.

One of the most common rotations in this area consists of corn, oats, and grass or clover. This usually is a 4-year rotation, the clover and grass remaining as a meadow or pasture for two or more years. Oats also frequently follow potatoes in a similar 4-year sequence, the oats in turn being followed by grass and clover. Where winter wheat is grown the rotation may consist of corn, oats, winter wheat, and grass. In this rotation winter wheat serves as a nurse crop, the grass seed being sown in the fall with the wheat, and the clover the next spring.

Soybeans, being an intertilled crop, have not replaced oats to any extent in the southern portion of this area. Further information on crop rotation in farming economy and the use of rotations in maintaining and improving soil productivity is given in Farmers' Bulletin 1475, Soil Productivity as Affected by Crop Rotation.

OATS IN MIXTURES WITH OTHER CROPS

Oats occasionally are grown in combination with other crops for either hay or grain. In this particular area a common combination is oats and Canada field peas. One bushel of oats and 1½ bushels of Canada field peas, or an equal mixture at the rate of 2 to 3 bushels to the acre, may be sown. In sections where peas do not grow so well a proportion of 1½ to 2 bushels of oats and ½ bushel of peas is common. The legume and oats in combination may increase both the yield and the feeding value of the crop, in addition to increasing the nitrogen content of the soil. Barley and oats in combination also are grown. When these crops are grown together it is necessary to use an early variety of oats, so that the two will ripen at the same time. Best results usually are obtained from sowing 1 bushel each of oats and barley to the acre.

Where rape will endure summer heat it is sometimes sown with oats, to be used as a pasture for hogs or sheep after the oats are harvested. From 1 to 2 pounds of rape seed to the acre is sufficient. Frequently the rape is sown from two to three weeks after the oats. The seed may be covered by harrowing lightly. Where rape is grown in the oats the oat crop usually is cut with a rather high stubble. Rape pasture is especially satisfactory for sheep.

OATS AS A NURSE CROP

As a nurse crop for clover and grass, oats are used more frequently than any other small grain. Spring seeding of alfalfa in oats is not uncommon in some sections of this area. While oats are not ideal for a nurse crop, because they draw heavily on soil moisture, good results as a rule are obtained. In dry seasons oats may tend to check the growth of the crop sown with them. When oats are used as a nurse crop the selection of fine-strawed, early varieties is desirable. Such varieties grow less rank and remove less water from the soil than larger-growing, longer-season varieties. When oats are sown as a nurse crop it sometimes is advisable to sow less than the ordinary quantity of seed, especially if a good stand of grass is the main objective.

OATS AS A COVER CROP

In the area under consideration oats are used to some extent as a cover crop in orchards. They remove considerable moisture from the soil, checking tree growth and causing young wood to mature fully before cold weather. Oats usually make a rather dense cover, and the close mat of dead plants furnishes considerable winter protection. This cover does not hold snow as well as some other cover crops. Peas or vetch may be sown with the oats when used as a cover crop. The best dates and rates of seeding for these cover crops depend largely on the local conditions and practices.

PREPARATION OF THE SEED BED

Frequently too little attention is given to the proper preparation of the seed bed for oats. In the Northeastern States oats generally follow corn. The land usually is plowed and fitted for seeding by disking and harrowing. In this area oats are sown much less frequently on soil prepared by disking and harrowing than in the Corn Belt. This is partly due to the weedy condition of the land following corn, and partly due to the difficulty of preparing a seed bed on the heavy clay soils of this area. When fall plowing is not feasible the land should be plowed as early as possible in the spring to give some time for the soil to settle and to become firm and compact. The best seed bed for oats consists of from 2 to 3 inches of loose, mellow soil on the surface with a rather firm layer of soil beneath. Wherever serious losses by erosion occur, fall plowing is not advisable. The plant residue remaining on land after harvesting the corn gives some protection against washing in the winter. Disking fall-plowed land for oats is shown in Figure 3.

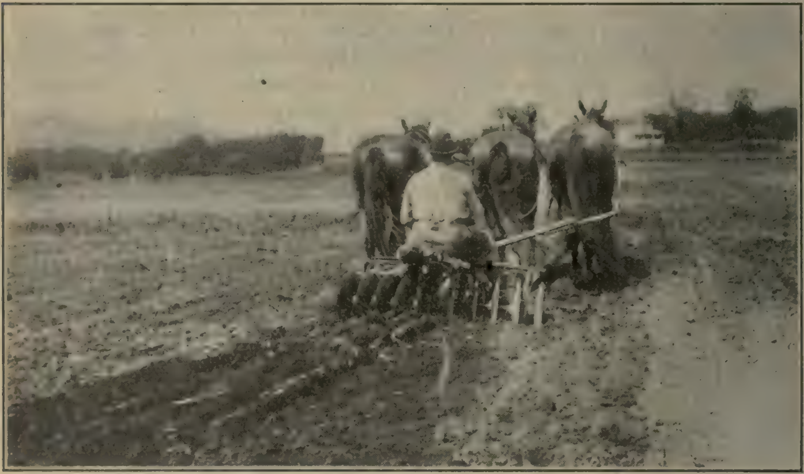

FIGURE 3.—Disking fall-plowed land for oats in the northeastern oat area

SEED PREPARATION

CLEANING THE SEED

Seed oats should be fanned and graded. A seed grader or an ordinary fanning mill is satisfactory for preparing the seed. Fanning removes the light oats and trash, while the small oats and most of the weed seeds are removed by the screens. Usually about one-fourth of the oats should be removed by fanning, although when oats are very light as the result of unfavorable seasonal conditions one-third or even one-half of the seed should be removed by grading and fanning. A large percentage of the small, light oats do not contain a kernel and would not germinate if sown. Seed of uniform size is desirable to facilitate accurate operation of the drill or seeder. The removal of weed seeds by fanning and screening is one of the effective methods for controlling and preventing the distribution of noxious weeds.

TREATING SEED FOR SMUT

Smut in oats frequently reduces yields materially. Two methods of seed treatment with formaldehyde are recommended to control smut. One is the so-called sprinkling method, and the other is the spray method.

If the sprinkling method is used, spread the seed oats on a clean barn floor or canvas, or in a tight wagon body, and sprinkle with a solution made by adding 1 pint of formaldehyde (37 per cent by weight) to 40 gallons of water. While the oats are being sprinkled they should be shoveled from one pile to another until every seed is well moistened, each bushel of seed requiring about 1¼ gallons of the solution. The seed should then be shoveled in a pile and covered with canvas or other covering and allowed to remain for at least two hours, or even overnight. The seed should be sown at once with allowances made in the rate of seeding for the swelling of the seed. If seeding is delayed the oats should be spread on a clean floor to dry.

The spray method differs from the one just described in that the oats are sprayed with a much stronger solution of formaldehyde. Mix 1 pint of formaldehyde (37 per cent by weight) with 1 pint of water and pour into a quart sprayer. This should be sufficient to treat 50 bushels of seed. While the spray is being applied shovel the oats from one pile to another. When spraying is completed, cover the pile with canvas or sacks that also have been sprayed with the solution. This covering should be allowed to remain on the oats for at least five hours, or overnight. The covering should then be removed and the grain should either be sown at once or spread out to aerate, as in the preceding method.

When grain has been treated with formaldehyde for smut disinfection it should not be allowed to come in contact with bins, bags, or machinery in which there may be smut spores. Usually it is advisable to treat the bags and the machinery along with the seed to prevent reinfection. Surplus treated oats may be fed to livestock without injury if spread out and aired for a few days.

For more complete directions in regard to these and other methods of using formaldehyde for smut control, see Miscellaneous Publication 21, Formaldehyde Seed Treatment for Oat Smuts.

Commercial chemical dusts may be used to control oat smuts with good results. These dusts are being used more and more each year because they are effective and also convenient to apply. As a rule, directions for using these dusts accompany the package or container.

SOWING THE SEED

TIME OF SEEDING

Owing to the rather short growing season in much of the area under discussion, especially at the higher altitudes, it is essential that oats be sown early. Late seeding frequently results in poor yields. Early seeding often permits the crop to escape injury from the effect of hot weather when the crop is nearing maturity. Ordinarily, frost or even light freezes after the seed is sown do not injure oats. A good rule to follow is to sow oats just as soon as the ground is in condition to work in the spring. Usually this can be facilitated by fall plowing.

In the Northeastern States oats usually are sown in April or early in May. However, the best seeding date for any section depends on many factors. Seeding usually is possible around April 15 in West Virginia, western Maryland, Pennsylvania, New Jersey, and New York. In the extreme northern portion and in the more mountainous sections of this area oats frequently are sown in May. In the New England States sowing during the first half of May usually is possible. Good results hardly can be expected if seeding is delayed until after May 15.

RATE OF SEEDING

The rate of sowing oats varies somewhat with locality, condition of the soil, method of seeding, and the size of the seed. On a poorly prepared seed bed more seed is needed than on a well-prepared seed bed. In drilling oats less seed is required than in sowing broadcast, because when sown broadcast many of the seeds are covered either too deeply or not at all and hence fail to germinate. In the Northeastern States the average rate of seeding is about 2½ bushels to the acre. The late, large-seeded varieties sometimes grown in this area should be sown at a rate of 3 bushels or more an acre.

METHOD OF SEEDING

Drilling is the best method of sowing oats. While use of the drill has increased markedly in recent years, a considerable portion of the crop still is sown broadcast. Drilling insures a more uniform distribution of seed as well as uniformity in depth of covering. This results in more even germination and a more uniform growth throughout the season. In dry seasons drilling places the seed in moist earth. Drilling also permits the sowing of clover and grass seed at the same time the oats are sown. If grass seed is not being sown with the oats, broadcasting is a quicker and cheaper method of sowing under some conditions.

The depth to which the seed should be covered depends on the nature of the soil and the amount of moisture it contains. With abundant moisture, shallow seeding from 1 to 1½ inches is sufficient. In loose, sandy loams, which lose their moisture easily, the seed should be placed at a depth of from 1½ to 2½ inches. When oats are sown broadcast the seed usually is covered by a shallow disking or by harrowing the soil with a spike-tooth harrow.

TREATMENT AFTER SEEDING

About the only treatment practiced after seeding in the Northeastern States is rolling. This is not always advisable, especially when seeding has been delayed by excess soil moisture resulting from continuous rains. Rolling sometimes is beneficial when oats have been sown in a very dry, cloddy seed bed.

Large weeds, such as dock and milkweed, sometimes are removed from oat fields by digging or pulling by hand. Although laborious, this is a good practice, as it is one means of weed control. While some oats may be destroyed in weeding, this loss will be more than compensated for by the destruction of noxious weeds and their seeds.

HARVESTING THE CROP

CUTTING

Oats in the Northeastern States usually are cut with a grain binder, although in the rougher and more hilly sections some oats still are cut with the cradle and bound by hand. In other sections cutting with a mower sometimes is necessary, especially if the crop is badly lodged or when the straw is very short, owing to drought or other unfavorable conditions.

The proper time to cut oats is when the grain is in the hard-dough stage and the straw still a little green. Earlier cutting usually results in shriveled grain and reduced bushel weight. If oats are allowed to become too ripe before binding there is danger of loss by shattering. Storms may damage the crop if harvest is delayed unduly. Where oats are cradled, they ordinarily are cut a little green. Sometimes they are allowed to cure a day or two in the swath before being bound. On the other hand, if not too green they may be bound as cradled.

The harvesting of a field of oats of the Ithacan variety in Cortland County, N. Y., is shown in the illustration on the title-page.

SHOCKING

In the area under discussion oats generally are shocked immediately after the binder. The shocks should be capped to prevent damage from rain and dew. If the oats are a little green or weedy, it may be advisable to let them cure for a few hours or a day in the bundle before shocking.

The round type of shock is mostly used in this region, although the long, narrow shock is favored by some farmers. A round shock may be built by several methods. One is to set up two bundles with the flat sides and heads together and the butts a few inches apart. These initial bundles should be set down firmly into the stubble, so they will stand alone. A bundle is then set at each end of the pair so there are four in a row; then a bundle is set in the middle of each side. Next a bundle is set in each of the four angles thus formed, completing the shock except for capping.

A modification of this method is to set the third and fourth bundles at the sides instead of at the ends, as just described. The fifth and sixth bundles are set at the ends and the shock is completed as before. If larger shocks are desired, a few additional bundles may be set around the shocks where they seem to fit best.

One or two bundles may be used in capping. A cap is made by holding a bundle with the butt on the leg above the knee and one forearm and hand under the bundle at the band, while half the straws are broken to the right and half to the left with the other hand. The position of the bundle may be changed so that the straws on the right are broken with the right hand and those on the left with the left hand. The shocks should be capped so that the broken straws of the cap will slant distinctly downward. If a cap of two bundles is used, the second should be placed at right angles to the first with the heads toward the direction of the prevailing winds. Two bundle caps, as a rule, afford better protection from rain and dew. If only one cap is used, the heads should be placed toward the direction of the prevailing winds. Skill in shocking and capping is especially desirable in the Northeastern States, owing to rains which frequently follow oat harvest. A properly constructed round shock is shown in Figure 4.

The long type of shock is started by setting the first pair of bundles in the same manner as in building the round shock, except that the butts should be set a little farther apart so as to permit free circulation of air lengthwise through the shock after it is completed. The second and third pairs of bundles are then set on opposite sides in a similar manner, with the bundles leaning slightly toward the first pair. Pairs of bundles are then set at each end alternately until the desired number is in place, thus completing the shock. In building a shock of this kind usually from eight to ten pairs of bundles are set up without capping.

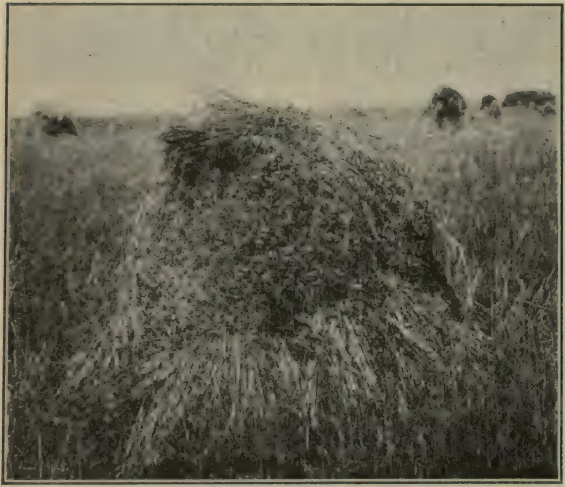
FIGURE 4.—A well-built round shock of oats with cap to protect the grain from weathering

STACKING

In the Northeastern States most oats are stored in barns until threshed. Stacking is little practiced, and in some sections it is almost a lost art. Owing to lack of barn space or other shelter, oats sometimes are stacked. It is important that the stacks be well built, otherwise they may not shed water and the grain will be damaged. An improvised foundation built of fence rails, poles, etc., usually is necessary to raise the stack a little above the ground to protect the lower portion of the stack from injury by ground moisture.

Stacking should be started from 10 days to 2 weeks after cutting. A convenient stack size is from 10 to 12 feet at the greatest diameter. Most stackers start building by first setting up bundles, as in making a large shock. Each successive round of bundles is set a little more slanting until a diameter of 10 feet is reached, when the last row will be almost flat. A row of bundles is then laid so that the butts form the outside of the stack base. The next row is laid with heads toward the center, the butts just covering the bands of the outer row. In a similar fashion rows of bundles are laid like shingles until the center is reached, the butts overlapping just a little more with each successive row, so the middle of the stack always will be slightly higher than the rim. Then begin at the outside and proceed as before with each succeeding layer.

In laying the outside row of bundles around the lower portion of the stack the bundles should be laid with the long straws of the butt on top. This will increase the diameter of the stack with each layer and form a bulge. After a height of 6 to 8 feet is reached the process should be reversed, the long straws of the butt being laid beneath, in this way gradually decreasing the diameter of the stack with each successive layer. The stack when so built tapers to a point when finished.

The most important essential in stacking is to keep the middle of the stack high and well tramped at all times. The outer rows of bundles should not be tramped at all. If there is danger of slipping, the so-called double and triple rows sometimes are laid in placing the bundles near the edge. Instead of laying just one row, two or three rows are laid in their proper position at one round of the stacker, the maximum number of bundles being thus laid with the minimum of tramping near the edge of the stack.

In completing the stack, the capsheaf or top bundle should be secured by driving sharpened stakes into the top of the stack. Stacks in this area sometimes are protected by being covered with tarpaulins.

THRESHING

When oats are stored in barns, threshing may be done when most convenient and usually after they have gone through the sweat and are cured completely in the mow. The thresher should be cleaned before threshing is begun to prevent the mixing of varieties and the dissemination of noxious weed seeds from one farm to another. Where oats of improved varieties are being produced, especially for seed purposes, too much care can not be given to avoiding mixing. The essentials of good threshing are the removal of all grain from the straw without undue cutting of the hulls from the kernels by the cylinder teeth and being sure that the separator is cleaning the grain reasonably well.

COMBINING

In recent years the use of the combine (combine harvester-thresher) for harvesting small grains has spread to all sections of the United States. An increasing acreage of oats is being harvested with the combine in the Northeastern States each year. Oats must be fully ripe before being combined. Ordinarily, when all greenness has left the straw and the glumes turn a dull white, combining should begin. If combined earlier or when too wet, the grain may spoil in the bin.

OAT STRAW

In the Northeastern States oat straw is of considerable value as forage and also as bedding for livestock. Usually, all oat straw is saved. It is protected from weathering either by being stored in barns or sheds or by being carefully stacked. Owing to its greater palatability, oat straw is preferable to other cereal straws as roughage for livestock. All oat straw not needed for roughage should be converted into manure and returned to the land.

By using a bunching attachment, oat straw may be saved when the grain is harvested with a combine. The straw is dropped in bunches which can be loaded conveniently on wagons and hauled to barn or stack. A hay loader may be used in picking up and loading the straw.

VARIETIES

The adaptation of different varieties to certain definite conditions of climate and soil is one of the most important considerations in the production of oats. The lack of satisfactory adapted varieties tends to limit the acre yield of oats in the Northeastern States. Relative productivity largely determines the place and usefulness of a variety. Other desirable characteristics that contribute to productiveness are disease resistance, stiff straw, and thin hull. Poorly adapted and inferior varieties should not be grown.

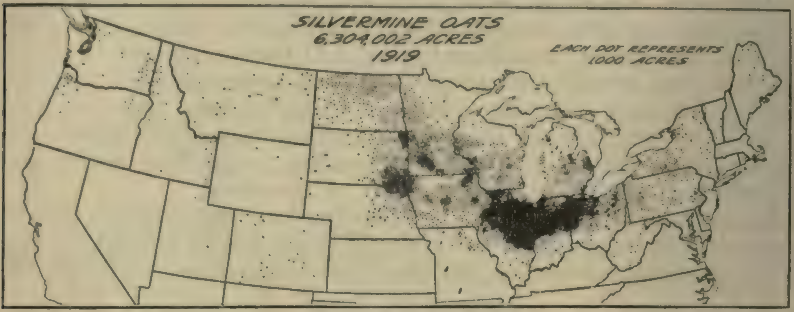

FIGURE 5.—Outline map showing distribution of Silvermine oats in 1919. This variety ranked second in importance to Swedish Select in the Northeastern States in 1919

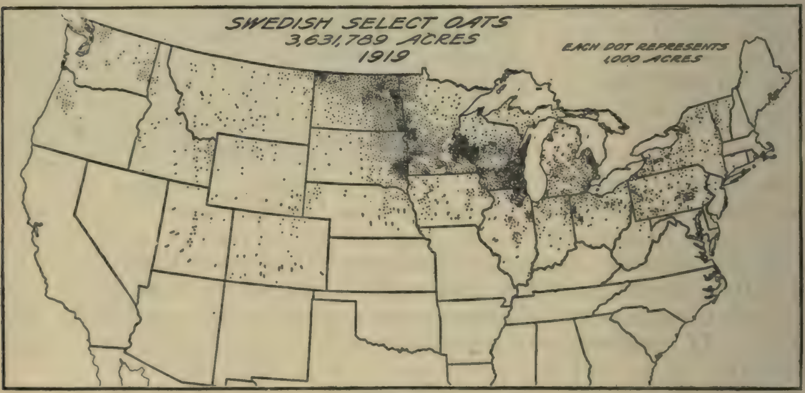

FIGURE 6.—Outline map showing distribution of Swedish Select oats in 1919, the leading variety grown in the Northeastern States at that time. The improved varieties, such as Keystone and Patterson in Pennsylvania, Cornellian, Ithacan, Upright, and others in New York, and Maine No. 340 in Maine, have replaced Swedish Select and Silvermine varieties to a considerable extent since 1919

VARIETAL FORMS

Oat varieties usually are grouped as early, midseason, or late in maturity. Of these three groups, the midseason varieties are of most importance in the northeastern area. Nearly all of these varieties have an equilateral or branching panicle. The late varieties with side or horse-mane panicle are less productive, and they are being grown less extensively than formerly in this area.

The early varieties, Kherson and Sixty-Day, and selections from them, such as Iowar and Gopher, are well adapted to the climatic and soil conditions of the southern portion of the northeastern oat area. Experimental data show, however, that these early varieties are not as productive on an average as the larger and slightly longer-growing types, such as Silvermine, Swedish Select, and Victory, in northern Pennsylvania, in New York, and in the New England States. The distribution of the standard varieties Silvermine and Swedish Select in the United States in 1919 is shown in Figures 5 and 6, respectively.

IMPROVED VARIETIES

For many years standard midseason, white-kerneled varieties, such as Silvermine, Swedish Select, Irish Victor, and Welcome, have been largely grown in this area. In recent years a number of new and improved varieties and strains have been developed. The Office of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, in cooperation with the department of plant breeding at Cornell University, has developed the following varieties: Cornellian, Comewell, Empire, Ithacan, Standwell, and Upright. Panicles and spikelets of the Cornellian and Upright varieties are shown in Figure 7.

Cornellian (Reg. No. 50).—This is one of the most popular of the new varieties grown in this region, especially in New York. It originated as a pure-line selection from a mixed variety called Canada Cluster. Cornellian produces a rather tall straw with slender, awnless, gray kernels. Its superior characteristics are high yield and low percentage of hull. Cornellian has the added advantage of being easily identified and maintained in a pure condition. It is recommended primarily for growing in New York State. Little or no objection is offered to the gray color of the kernels, as most oats in that State are fed to domestic animals on the farms where they are grown. Cornellian has proved to be ideal for growing in combination with Alpha barley for a grain mixture. Both are high-producing varieties and ripen at approximately the same time.

Comewell (Reg. No. 54).—This oat originated as a head selection from the Welcome variety. It is a midseason, white-kerneled variety of the Silvermine type. Because of its high yield and high test weight, Comewell has been grown considerably in New York; yet newer and still more satisfactory varieties are being developed and distributed which are now replacing it.

Empire (Reg. No. 55).—This selection originated as a head selection from Big Four, a midseason, white-kerneled commercial variety. It is similar to Comewell in plant and kernel characters. Its superior qualities are high yield and high test weight per bushel.

Ithacan (Reg. No. 58).—This oat resulted from a head selection of the National variety. It is a midseason white oat, similar to Silvermine. It is a promising variety in a number of sections in New York State.

Standwell (Reg. No. 60).—This oat originated as a head selection from Lincoln. It is a midseason white oat, resembling Lincoln, and is popular in New York State because of its quality, yield, and rather stiff straw. It has outyielded Silvermine by an average of about 5 bushels per acre.

Upright (Reg. No. 61).—This variety resulted from a pure line of the old oat known as American Beauty, which has been grown for years in Jefferson County, N. Y. It is similar to Scottish Chief, a midseason, white oat, formerly grown in New York and adjacent States. Its stiff straw and high yielding ability have made it popular on dairy farms where considerable manure is applied to the land. Its ability to stand up where most other varieties lodge is its most valuable asset.

In addition to the above-mentioned varieties, other improved strains have been developed independently by State agricultural experiment stations. Among the most important of these are Patterson and Keystone, developed by the Pennsylvania station, and Maine No. 340, developed by the Maine station. Victory, an introduced improved variety from Sweden, also should be mentioned. Panicles and spikelets of the Patterson and Maine No. 340 oat varieties are shown in Figure 8.

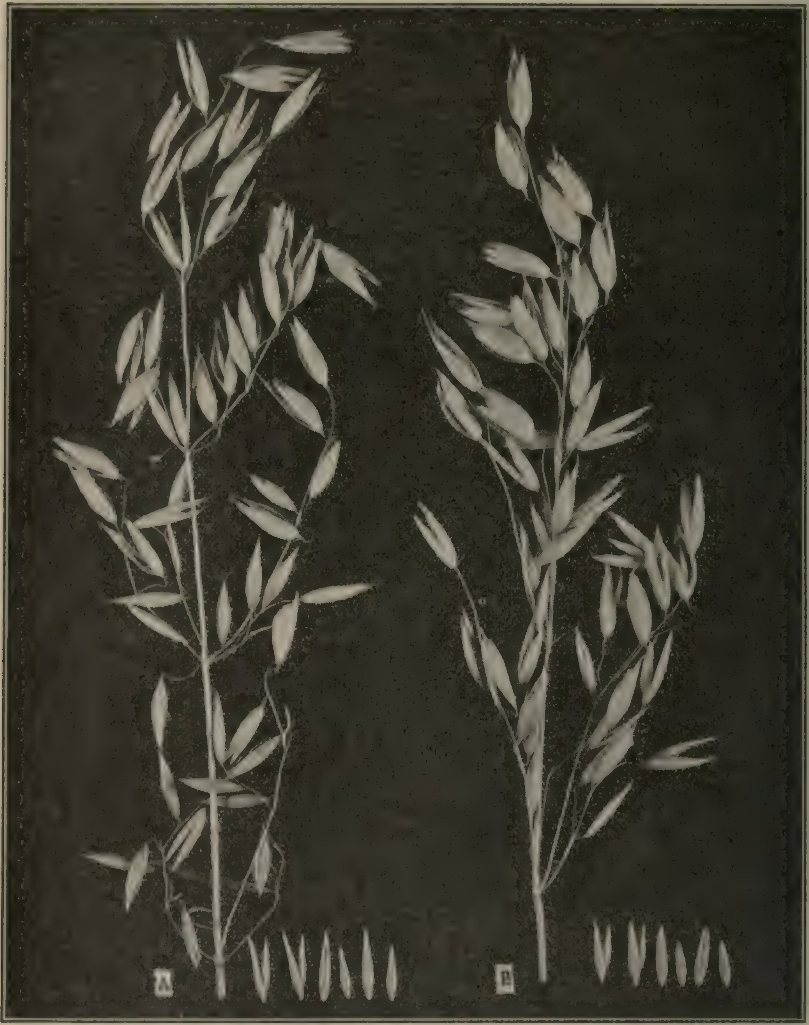

FIGURE 7.—Panicles and spikelets of the Cornellian (A) and Upright (B) oat varieties

Keystone (Reg. No. 68).—Keystone is a pure line of an oat that has been grown in Pennsylvania for many years under the name of Japan. Keystone is early to midseason in maturity and produces yellowish-white kernels. It is best adapted to southern Pennsylvania.

Patterson (Reg. No. 69).—This variety has the same history as Keystone and is similar in plant characters. However, it has shown a rather more general adaptation throughout Pennsylvania and probably is the better variety.

Maine No. 340.—This is a pure-line selection from the old variety known as Irish Victor. It is a midseason, midtall variety with yellowish-white kernels.

It is the most important variety grown in Maine. Its superior yielding qualities, combined with a fairly stiff straw, have met with high favor among New England farmers.

Victory.—A selection from the old Probsteier variety, developed about 25 years ago at the Swedish Experiment Station at Svalof, Sweden. Victory is a midseason to late high-yielding variety with a fairly stiff straw and excellent kernel characters. It has been an important variety in the Northeastern States.

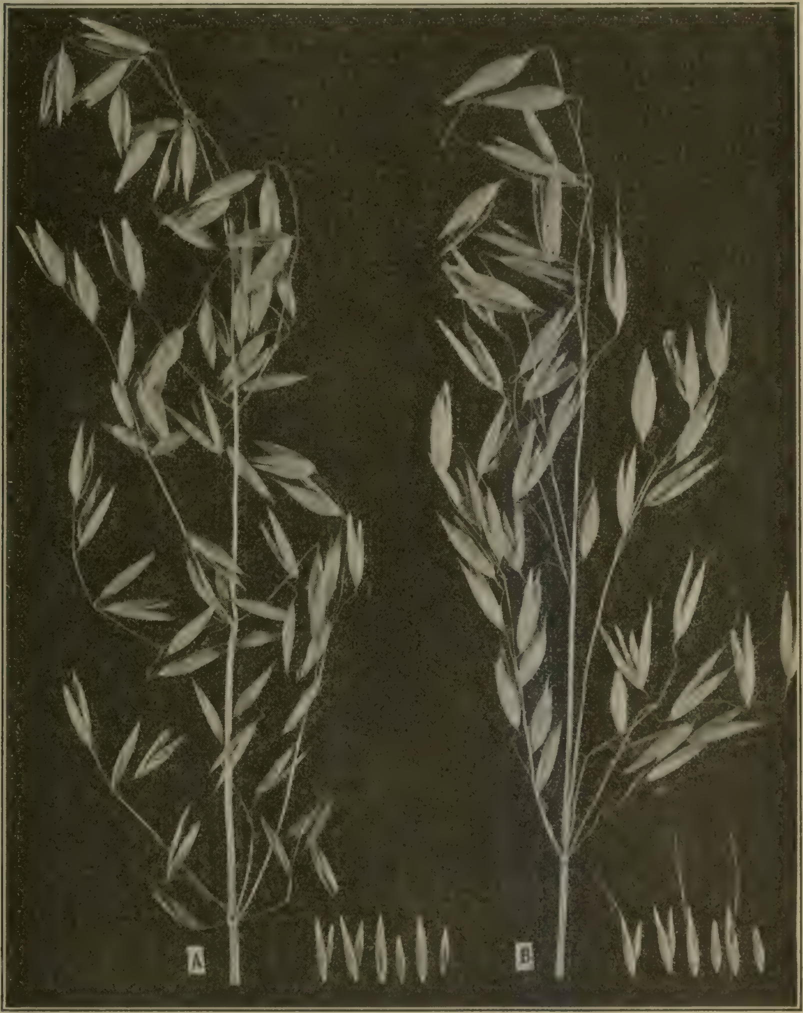

FIGURE 8.—Panicles and spikelets of the Patterson (A) and Maine No. 340 (B) oat varieties

In the western part of Virginia and in West Virginia and the northern tier of counties in Maryland improved early varieties developed in the Corn Belt section, such as Gopher, Iowar, and Richland (Iowa No. 105), have shown high yielding ability and are replacing to some extent the larger midseason varieties that have been grown most extensively in these sections. In New Jersey early oats also are to be recommended. Fulghum (Kanota), an early red oat, in recent varietal tests at the New Jersey Agricultural Experiment Station, New Brunswick, has shown promise of being a valuable variety. One objection to these early, short-strawed oats throughout the Eastern and Northeastern States has been their low yield of straw. As a by-product oat straw is relatively valuable for both forage and bedding. As a result, the later varieties with taller and larger stems frequently are grown to obtain a higher straw yield.

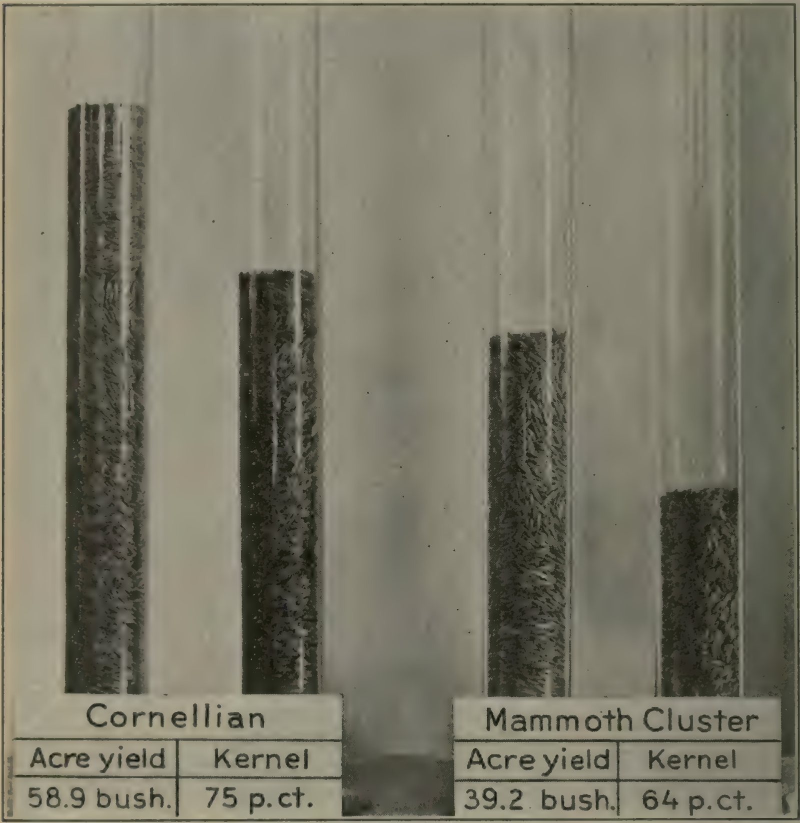

FIGURE 9.—Relative acre yields and percentages of kernel (meat) to hull in the Cornellian, a high-yielding, thin-hulled variety, and Mammoth Cluster, a low-yielding, thick-hulled variety, when grown in comparable experiments in New York

LATE VARIETIES WITH SIDE PANICLES

The late, large-strawed, large-seeded, thick-hulled varieties with side panicles, such as Storm King, Mammoth Cluster, Tartar King, and Canada Cluster, sometimes are grown in this area. As a group these varieties are much less productive than the best mid-season varieties with spreading or equilateral panicles, and they should not be grown. Farmers are attracted by their large, plump grain and good appearance in the field. However, they produce large, thick hulls (lemmas) and many so-called double grains (referred to as "bosom oats" in Canada) which give them a high percentage of hull and a low feeding value. The comparative yields of oats and kernel (meat) from Cornellian, a high-yielding, thin-hulled variety, and Mammoth Cluster, one of these side-oat varieties, obtained at Cornell University (New York) Agricultural Experiment Station, are shown in Figure 9.

Large, plump grains do not always indicate high yield and a high percentage of kernel. The proportion of kernel to hull is a very important character from the standpoint of productiveness and feeding value in any oat variety. As a result, these large varieties with side panicles can not be recommended for growing on farms in the Eastern and Northeastern States.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1660

The USE of LOGS and POLES IN FARM CONSTRUCTION

1862 1889

LOG-HOUSE CONSTRUCTION was well understood by the pioneers, but like other primitive arts with a simple technique, its principles are not so well known to the general public of to-day.

This type of building is adaptable to both temporary and permanent shelters for man and beast in those sections of the country where cut-over land is being brought into cultivation and in other localities where timber is readily available. In such regions a farmer just starting out can construct of logs and poles nearly all the shelters and many conveniences needed for his immediate use, thus obtaining a comfortable temporary home with the expenditure of little money and conserving his capital for the development of the farm and the building of a permanent home later.

The demand for information on the construction of log cabins and rustic work indicates renewed appreciation of the art and a desire for directions for utilizing logs and poles.

Washington, D. C.

Issued March 1931
Slightly revised April 1935

THE USE OF LOGS AND POLES IN FARM CONSTRUCTION

By T. A. H. MILLER, *Agricultural Engineer, Bureau of Agricultural Engineering*

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INTRODUCTION

LOGS AND POLES can be employed advantageously in the building of dwellings and other farm conveniences, by settlers or others establishing themselves in regions where timber is plentiful. This method of construction, in that it permits of utilizing local material and labor, saves capital for the development of the farm and the building of a permanent home later.

The principles of log construction are few and simple. However, they are not well understood by the general public of to-day. This bulletin outlines the chief points to be observed in building with logs and poles, and it is believed that one should have little difficulty in planning an attractive home and certain other useful structures after studying the text and illustrations.

SELECTING TREES FOR LOGS

THE SURVEY

Before starting construction, a thorough survey of the wood lot should be made to determine the number, species, and size of trees available and their sale value. Many species of trees have commercial value [1] which warrants their being left standing until convenient to market. By following this procedure considerable money might be available later for defraying the expense of building, or for other purposes; also, such a survey will be of help in determining the design of the proposed structure.

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[1] See Farmers' Bulletin 1117, Forestry and Farm Income; Farmers' Bulletin 1210, Measuring and Marketing Farm Timber.

SUITABLE SPECIES

As a matter of economy one should as far as practicable use the trees found on the site. When a choice of species is possible balsam, hemlock, tamarack, and pine are very good. Short-lived woods like the cottonwood, willow, aspen, birch, and basswood, unless very thoroughly protected from dampness are not so suitable. Cedar and white pine are excellent when it is not possible to market them. Many of the hardwoods are almost as desirable but are less frequently used, chiefly on account of their weight and hardness. Other species can be used, but it is advisable to choose the more durable woods and for the sake of appearance to employ the same species in like parts of the building.

SIZE OF LOGS

Logs of from 4 to 10 inches in diameter are usually employed, yet larger logs are not uncommon and it is desirable, though not essential, that the logs have only a slight taper. The length of the logs should preferably be a little greater than the length of a room, to allow for intermembering; tree trunks longer than 20 feet are heavy and difficult to handle, and longer ones are seldom necessary since the length of a room does not often exceed 20 feet. While logs used in a wall can be spliced by halving the abutting ends, this is not considered good practice as it weakens the wall and detracts from the appearance. Short lengths can be utilized for panels between wall openings, as explained on page 14. By careful designing, details can be worked into a structure so as to make use of a large number of short lengths of small-diameter logs, thus utilizing to advantage a limited supply of timber and at the same time effecting a saving in the large trees and in the amount of labor required in building.

TIME OF CUTTING

If the logs are to be peeled, winter is the best time for felling the trees, for if felled in the spring while the sap is running, the logs deteriorate on account of the development of stain and decay organisms. Department Circular 421, The Control of Stain, Decay, and Other Seasoning Defects in Red Gum, describes resisting treatments which also minimize end checking. Bark will adhere to the logs if the trees are cut in the late summer, but to avoid insect injury the cutting should be postponed until about the time of the first frost. To increase the adhesion of the bark, a narrow strip or score should be cut off on two sides of the entire length. The logs should then be seasoned by piling them in the shade so as to allow thorough circulation of air, until the following spring or summer. The scores, ends, and knots should be painted with coal-tar creosote a few days after the trees are felled and again just before the timbers are used. When not scored as suggested, the bark should be tacked to the logs with large-headed nails, using one to every square foot of surface. Sometimes the bark is nailed on without particular attention to the time of cutting or other treatment.

Unpeeled logs have a more attractive appearance than peeled logs, but there is no practical advantage in keeping the bark on the logs.

In fact, peeled logs are to be recommended for the more permanent structures since they are less subject to rotting and can be better protected against insect attack. Sometimes logs are stained, creosoted, or painted. Staining is probably to be preferred, for the odor of creosote, which is rather persistent and penetrating, is objectionable in a dwelling. Even though the logs are not painted, it is advisable to apply a protective coating to the cuts made by notching at the corners. This is especially recommended when bark is to be kept on the logs.

PROTECTION OF LOGS FROM INSECTS

Woods cut at certain seasons of the year are subject to attack by beetles which fill the bark with holes, causing sawdustlike borings to fall out and lodge on the wood. The larvae or grubs of wood-boring beetles mine the inner bark, causing the outer bark to loosen and fall off; and they bore into the sapwood and sometimes the heartwood of the logs, making large holes and often reducing them almost to dust within a few months, before the wood becomes well seasoned. Methods of reducing injury to poles by insects have been developed by the Bureau of Entomology. Before cutting logs, the recommendations of that bureau [2] should be studied thoroughly, as considerable trouble after the logs have been used in a structure may thus be avoided.

CHOICE OF SITE

In general, a site should be chosen for its suitability for the main purpose, good water and drainage, accessibility, and orientation. The settler is principally concerned with the adaptability of the site to the final plan of his farmstead, and he therefore should not locate the temporary log buildings on the exact spot on which he proposes to place his permanent structures, but should so locate them that they can be utilized in the final layout either as wings of a new building or as separate structures. Farmers' Bulletin 1132, Planning the Farmstead, discusses the location of the farmstead with regard to the fields and also the relation of buildings one to another with respect to efficiency in the performance of routine operations.

A dwelling always should be located on a well-drained spot and so oriented that advantage may be taken of restful vistas, cooling summer breezes, and protection from storms. Discretion should be exercised in preparing the site, for the indiscriminate altering of the topography or the ruthless cutting of trees in the immediate vicinity of the structure may rob the site of much of its natural charm and leave the surroundings bare and uninteresting. Frequently shrubbery can be transplanted so as better to fit into the proposed scheme of landscaping.

In selecting the site, the builder of a new home should give consideration to the foregoing suggestions relative to attractive surroundings for they frequently serve in some measure to compensate the housewife for the denial of comforts which is sometimes inevitable in the first years of the struggle to establish a new home.

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[2] Farmers' Bulletin 1582, Protection of Log Cabins, Rustic Work, and Unseasoned Wood from Injurious Insects; Farmers Bulletin 1472, Preventing Damage by Termites or White Ants.

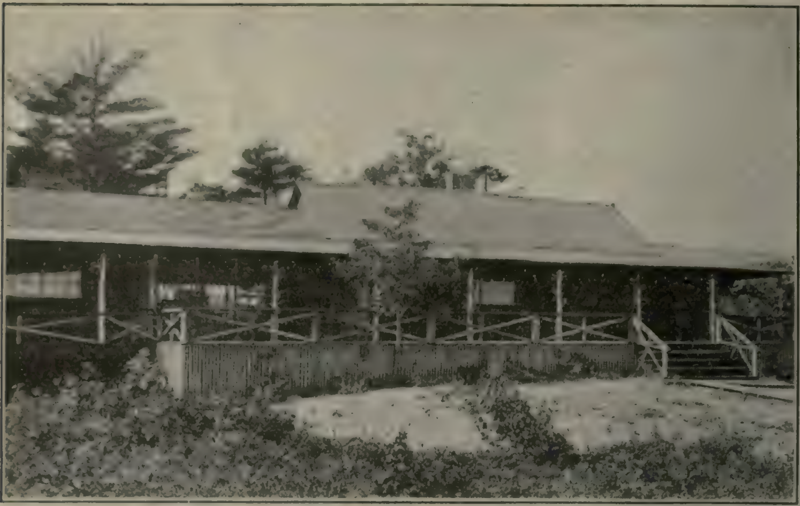


FIGURE 1.—The long wings and large porches suggest a clubhouse. Note the use of small poles for closing-in under the porch and the screened-in porch which provides a large room with the use of very little material

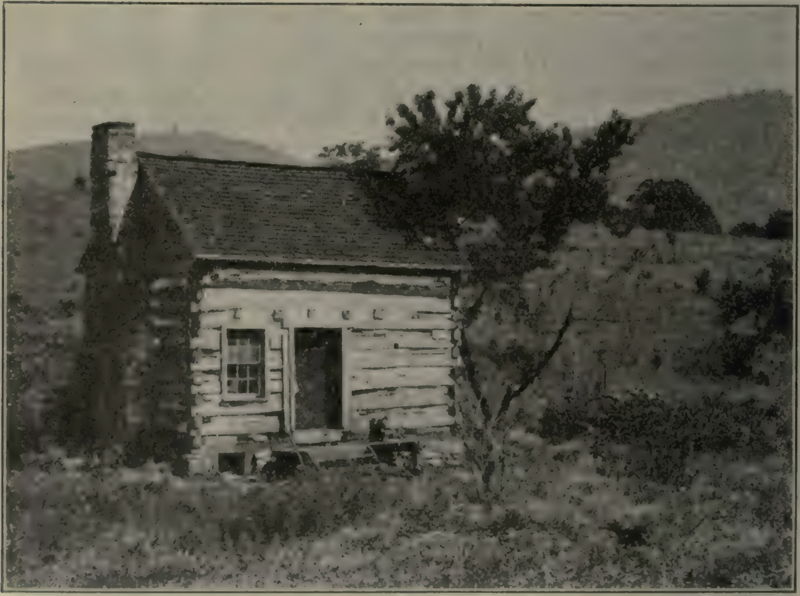


FIGURE 2.—The plainness of this cabin is accentuated by the bareness of its location. Generally, large hewn logs of chestnut or oak were used in building cabins in the Eastern States, a fact which accounts for the long life of the structures. Note the type of corner joint typical of this region and the method of extending the second-story floor joists through the walls

Farmers' Bulletin 1087, Beautifying the Farmstead, contains suggestions that will be found useful in this connection.

Much of the pleasure of living in a log house built for recreational use is dependent upon the site; therefore, if a choice of sites can be had, consideration should be given to accessibility to a main road. Side roads are likely to become almost impassable at times, making travel and conveyance of supplies very difficult. While a secluded spot may be desirable, its advantages often are lessened if access is difficult.

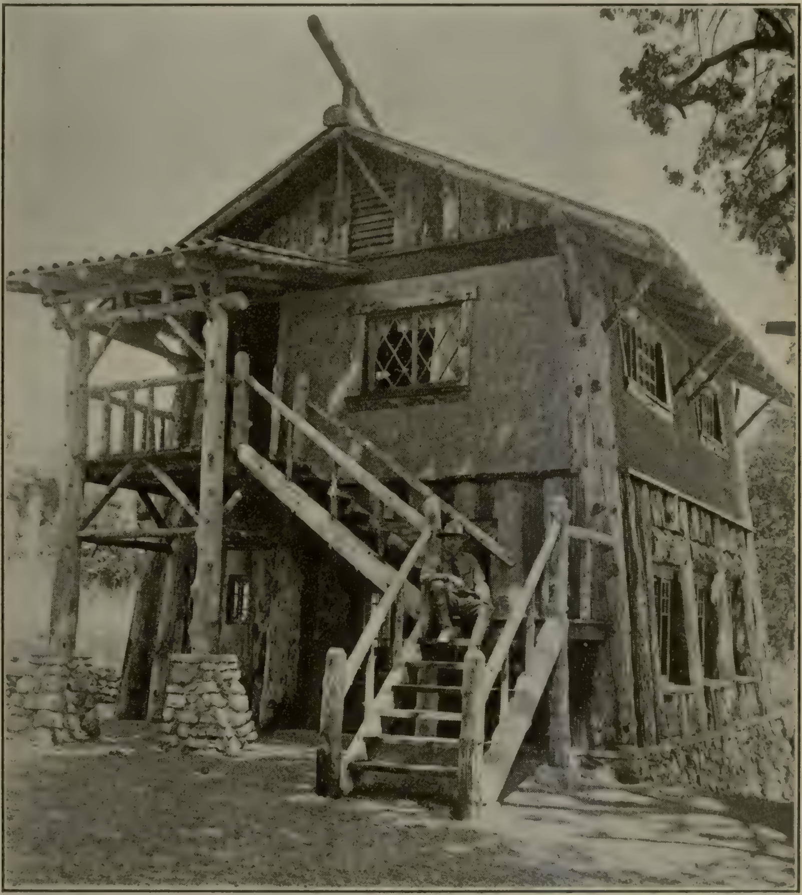


FIGURE 3.—An unusual design which is shown here on account of the details illustrated

METHODS OF USING LOGS

Log construction permits of a wide range of treatment and may be made very attractive. However, the design should suggest the general purpose of the building. (Fig. 1.)

In style, the log house varies from the severely plain hewn-log cabin (fig. 2) to elaborate creations often displaying considerable originality (fig. 3). Perhaps the most fruitful sources of suggestion,

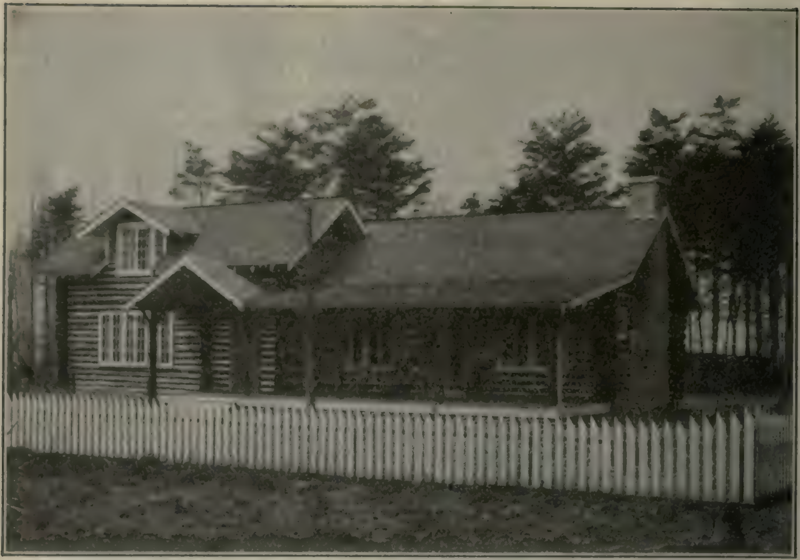


FIGURE 4.—A carefully built farmhouse, with 6-inch logs laid horizontally. Colored mortar might have been used for the chinking

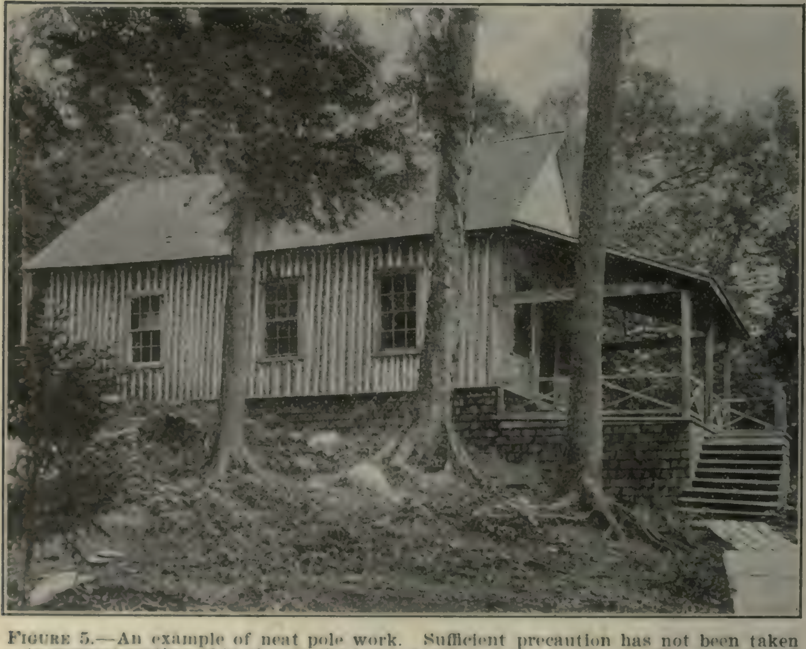


FIGURE 5.—An example of neat pole work. Sufficient precaution has not been taken to prevent rotting of lumber in the lower portion of the structure. The rear should be raised clear of the ground and ventilation openings provided in the tight shingle inclosure around the foundations

as to the effective use of logs, are photographs of structures that have been built. A large number of pictures are used in this bulletin to illustrate methods of employing logs. While some of the designs shown may appear rather ambitious, yet their execution requires only a little extra labor and material at practically no additional cost. Prospective builders will do well to study these illustrations and make use of the suggestions, thus obtaining a better appearing house than they might otherwise consider to be within their reach.

There are two general methods of using logs in walls, the most usual one being that in which they are placed horizontally (fig. 4), and the other where they are set vertically (fig. 5). Sometimes a combination of the two methods is used in the same structure, (fig. 6), and frequently poles are used only for the frame of a building (fig. 7).

Where the logs are laid horizontally the appearance of the walls is materially affected by the size of the logs, the method of working them, and the type of joint used for intermembering. If a rustic effect is desired, round logs are selected and care is taken to preserve the bark. Neatness of appearance is attained by using logs of uniform diameter and taper. (Fig. 4.) A pleasing variation is obtained when the logs decrease uniformly in diameter from the foundation to the plate so as to produce a batter to the walls. Substantiality is suggested by heavy logs (fig. 8) and ruggedness by logs which are irregular. Frequently logs are hewn on two, three, or four sides and if of large diameter they can be hewn to a thickness of from 8 to 12 inches and laid with the wide face vertical. In some sections the logs are flattened slightly at top and bottom so that the upper ones bear upon the lower ones throughout their lengths, while frequently they are laid with an intervening space of from a fraction of an inch to one almost equal to the diameter of the log. The space between the logs is determined by the depth of the notch at the corner where logs of adjacent walls intermember. If the logs

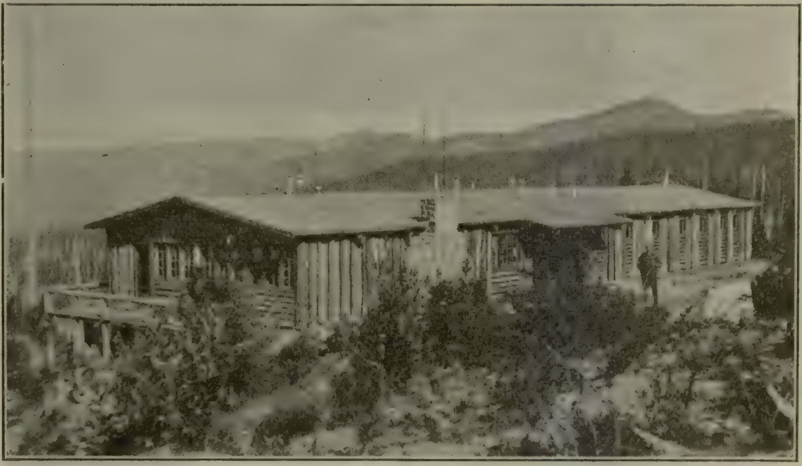


FIGURE 6.—An easily built structure. Logs are used vertically between windows and horizontally at the openings

are hewn so as to fit quite closely, the building will have a substantial appearance and considerable labor in caulking and chinking will be saved.

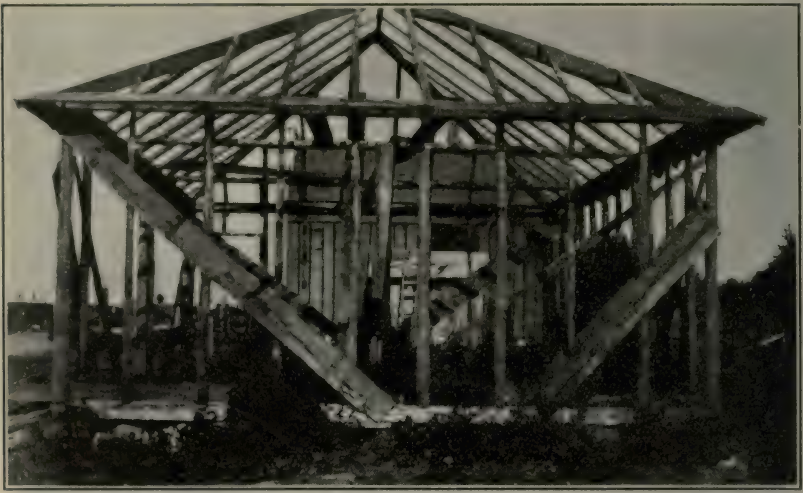


FIGURE 7.—The 4-inch poles of this 24 by 27 foot house were peeled and erected by one man in three days. (Courtesy of the Michigan Agricultural College)

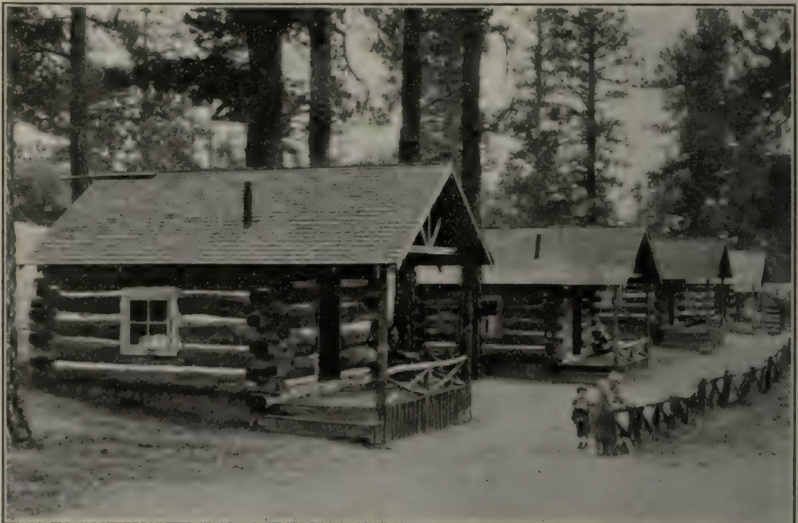


FIGURE 8.—Very substantial cottages; note the corner joint employed and the method of building the casement window to permit the sash being opened out flat against the wall

NOTCHING

Various methods are used for intermembering and terminating the logs at the corners. A number of the cuts and notches are illustrated in Figure 9; other types are clearly shown in the photographs. The sketch in left center of Figure 9 shows the detail used for the corners of the house illustrated in Figure 10 which differs radically from pioneer methods. The ends may be left irregular, sawed off vertically, or sawed on a batter so that the base log has the greatest projection and the plate log the least. (Fig.11.) The cracks or spaces between the logs must be sealed, but this operation should be delayed as long as it is practicable so that the logs will have an opportunity to dry out or season.

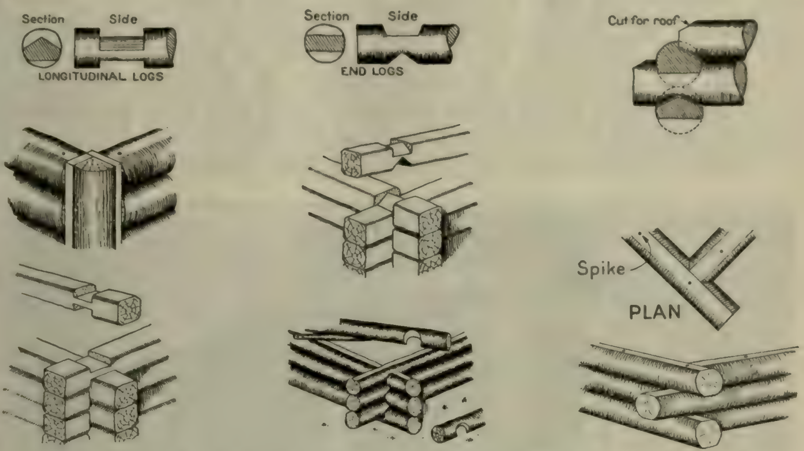


FIGURE 9.—Methods of cutting and notching logs for corners

CHINKING AND CAULKING

If the joints are laid close, the narrow cracks may be caulked with cotton waste, oakum, or sphagnum moss—the moss found in swamps and used by florists for wrapping plant roots. This is forced into the joints from both sides of the logs with a wooden wedge or a caulking iron struck with a mallet. If the joints are wide, they may be closed with short lengths of quartered logs shaped to fit the cracks,

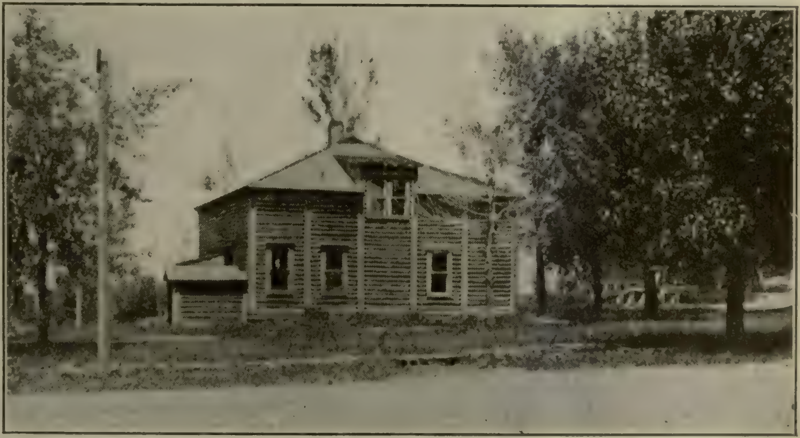


FIGURE 10.—The corner logs of this house are not intermembered

bedded in mortar, and nailed in place. (Fig. 12). To assure watertight walls it frequently is necessary to insert chinks both inside and outside and then to plaster over them with mortar. Sometimes nails are driven into the logs with heads protruding to form a key for cement mortar which may be used for stopping joints that are not too wide. Where the logs have been laid in crib fashion, the spaces are filled with clay, lime mortar, cement mortar, or pieces of slab stone laid at an angle of 45° to 60° and bedded in mortar, thus causing the wall to appear as alternate layers of masonry and timber. Farmers' Bulletin 1279, Plain Concrete for Farm Use, describes how to make a good 1-to-3 mortar such as is suitable for filling in and for bedding slab stone. Before filling wide spaces between the logs with mortar, narrow strips of expanded metal should be fitted and securely nailed between the logs to serve as reinforcement and as a background for the mortar. Clay for chinking is mixed like mortar, to the consistency of putty and pushed into the joints. When well done clay chinking will last from 10 to 12 years and may be used as a temporary filling for minor farm buildings.

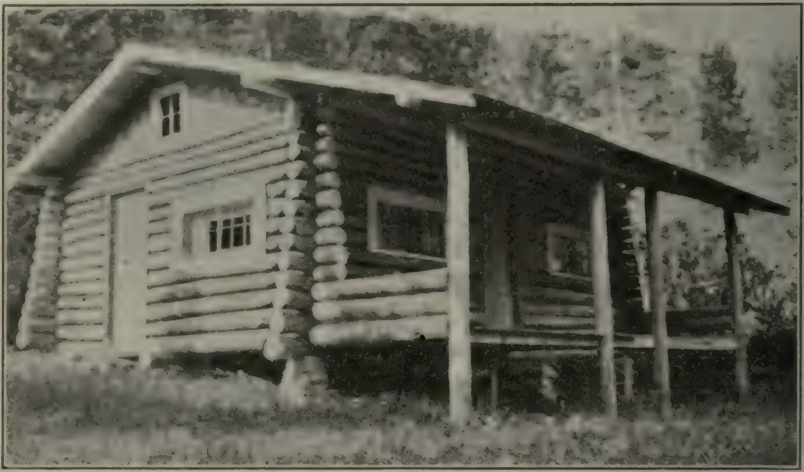


FIGURE 11.—Logs vary uniformly in size from base to plate and cut off on a batter. Rear piers should be higher than shown here in order to keep logs off the ground

CONSTRUCTION

POLE HOUSES

Buildings with walls made by placing logs on end (fig. 5) are commonly referred to as pole houses. Such structures are easier to build than those in which the logs are horizontal because one man can handle the logs which generally are of short length and small diameter. Moreover, the labor of notching at the corners is not required.

This use of logs is admirably suited to small buildings and lends itself to considerable variation in architectural expression. However, such structures are not so substantial as log houses. The poles should not be less than 4 to 5 inches in diameter and if of uniform diameter and taper they produce a neat effect. If a weather-tight wall is desired, the logs should be hewn on the sides and matched to fit closely. The cracks are chinked in the same manner as in log houses. A good foundation should be provided upon which should be bolted square sill logs equal in diameter or hewn dimension to that of the wall poles. The top surface of the sill must be smooth and level to provide proper bearing for the sawed ends of the poles. Similar logs must be used for plates over the tops of the verticals. The sills and plates should be halved and lapped at the corners. The corner uprights should be set first and the plates then placed on top of them. The wall uprights are then matched and fitted between the sills and plates and spiked in place. Other details are executed in a manner similar to that described for log houses.

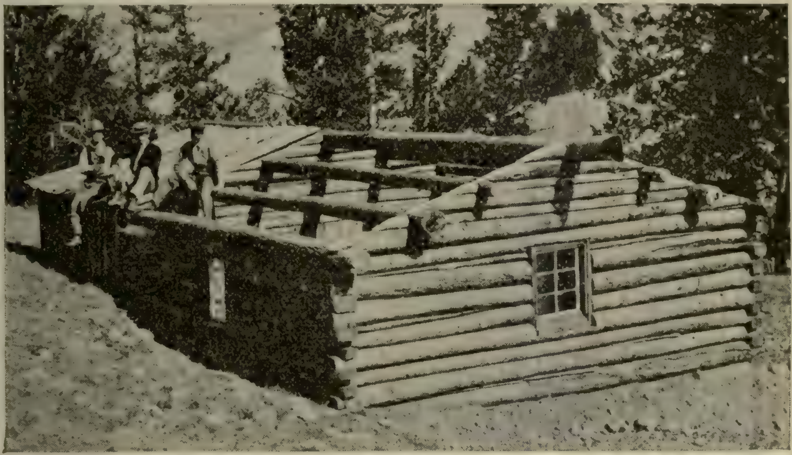


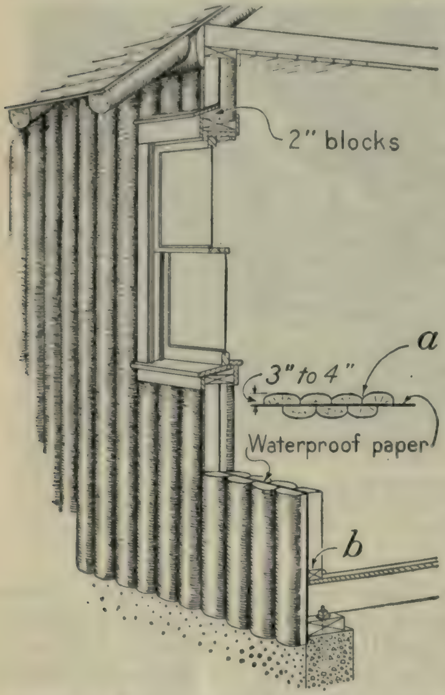
FIGURE 12.—Note the chinking between logs and the method of forming gables with horizontal logs. The location of this house is unfortunate as the hillside drains water onto the site. Also the bottom logs are in contact with the ground; unless the site is carefully graded to carry water away from the structure conditions are very favorable to decay

Split logs and slabs are sometimes used in the manner shown in Figure 13; two layers of logs or slabs are used, with staggered joints and roll roofing or heavy building paper between. Edges of slabs should be cut to make close joints, *a*, and sill thickness should at least equal that of floor and quarter-round *b*.

LOG HOUSES

There is nothing complicated in log-house construction. The main difficulty lies in the amount of heavy work necessary. After the general method of using logs and the type of joint have been decided upon, a sketch should be made from which the number and sizes of the various logs can be determined. Methods of building various details are outlined herein, and these can be varied to suit individual preferences or requirements. In general, details are similar to those used in frame construction; however, it is very important that the details afford protection against dampness which promotes decay. If wood is always kept dry there is little danger of decay; wetting by storms is not detrimental if the wood dries out quickly and water does not collect in the joints and remain there. Wide eaves help to keep storm water away from the walls and foundation. Proper grading will drain surface water from the building. Figure 12 shows an example of a poorly graded building site. Joints at corners, around openings and between logs should be constructed and protected so that water cannot collect and remain in the wood. Foundations should be designed to keep logs off the ground and to afford a means of ventilating the underside of the floor.

FOUNDATIONS



Method of framing small split logs or slabs vertically. (Method recommended by University of Wisconsin.)

The first consideration is a suitable foundation the character of which is determined by the degree of permanence required. So far as possible local stones should be used. If the house is to be occupied the year round, a full masonry wall is advisable; this may be of concrete or of stones laid in cement mortar. If there is no cellar under the structure, a number of screened holes about 4 inches wide and 8 inches high should be provided in the four sides of the foundation to ventilate the underside of the floors and thus reduce the danger of timbers rotting. Note the lack of ventilation openings in the shingle inclosure under the house in Figure 5. The foundation wall should be from 2 to 3 inches wider than the diameter of the logs, but in any case not less than 8 inches wide. The width of the footing, or bottom of the foundation wall, will depend upon the character of the soil. In general, if the footing is 8 inches wider than the wall thickness it should prevent settlement unless the soil is very soft. Local requirements can be ascertained by examining structures in the vicinity built on similar soils.

The simplest support for temporary structures consists of large, flat stones laid on firm ground, and it is advisable to use two stones, one on top of the other. The top stone prevents ground moisture from rising by capillarity to the sill which is thus protected from rotting. If stones are not readily available and termites need not be guarded against, mud sills or heavy logs laid on the ground can be used for the foundation of temporary buildings. Wooden posts 10 to 12 inches in diameter are frequently used and should be of cedar, locust, or other durable wood unless creosoted. Instructions for creosoting are given in Farmers' Bulletin 744, The Preservative

Treatment of Farm Timbers. Posts should be set in the ground at least 3 feet with the lower ends resting on flat stones. They should be placed at the corners of the building and at points 5 to 10 feet apart under the walls and cross girders. Concrete and masonry piers are preferable because of their durability.

LAYING UP THE WALLS

The heaviest and best logs should be used for sills or bottom logs, and care should be taken to see that they bear firmly on the piers and do not rock. If the foundation is a continuous wall both the top and bottom of the sill logs should be hewn flat, but if the building is supported on piers only the upper surfaces and the bearings on the piers are flattened. Sills under cross walls should be halved into abutting sills and tree nailed or heavily spiked. Care should be taken to make the tops of all sills level. The notches in the ends of the wall logs should be of such depth that the logs are almost in contact. If they are not hewn flat, bends and knots should be trimmed to make a fairly tight fit. As the logs are notched and placed they should be fastened to the lower tiers at the corners with sixtypenny or longer spikes. A good method of fastening logs, especially when not notched at corners (fig. 9, upper left-hand sketch) is to bore ¾-inch holes 3 or 4 feet apart, or closer if need be, in the upper side and half way through each log so that sixtypenny spikes, when driven into the holes, will penetrate the next lower tier. The holes should be staggered in alternate tiers to avoid driving the spikes into the holes of the lower logs. A ⅝-inch round iron punch is used for driving the spikes firmly into the bored holes. These spikes form a good anchorage for fastening the strips of metal lath recommended on page 10. To prevent one corner of the building from rising higher than another the butts and tops should alternate in direction, and as a precaution it is advisable to test the level of the wall at several stages before the top log or plate is reached.

OPENINGS IN WALLS

A common fault of log houses is that too little window area is provided, and consequently the interiors are dark and gloomy (fig. 14); the cost of obtaining plenty of interior light is money well spent. Casement windows are more in keeping with log construction than are double-hung sash, and these should open outward to exclude rain. (Fig. 8) This type of window is economical as it does not require much millwork or hardware. Where there are mosquitoes, screening will add much to comfort. Windows and doors can be installed as in ordinary frame structures after the opening is cut in the log wall.

When only long logs are used for the walls no attention is paid to the openings, except, where possible, to place a poor part of the log where it will eventually be cut out. However, when the top of a window or door is reached, the top log of the opening is cut out; thus provision is made for cutting out the full opening later. The next tier then forms the lintel. The openings can best be cut by means of a 2-man saw guided by a 2-inch vertical plank temporarily nailed to the face of the wall. False jambs (2-inch plank from 4 to 10 inches wide and the full height of the opening) should be spiked to hold the ends of the logs. Before the opening is cut, the outside dimensions of the window frame should be determined. The opening should then be cut about 4 inches wider to allow for the false jamb. If sash is to be installed without frame, the opening should be 4 inches wider and longer than the sash. (Fig. 15.)

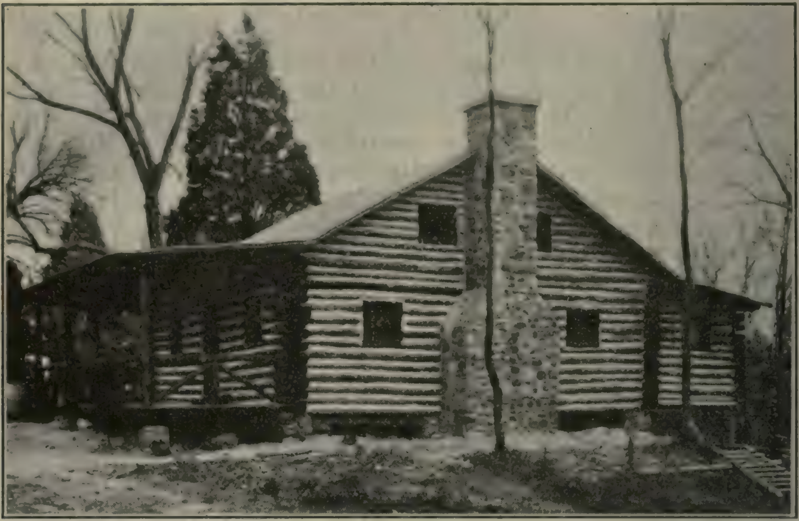


FIGURE 14.—The small windows detract materially from the appearance of this house and cause a dark interior

When short logs are employed for panels between openings, they should be cut to a length equal to the width of the panel, and held in place by false jambs. Care must be taken, however, to provide long logs which extend the whole length of the wall, or at least across several panels, at sill and lintel heights so that the wall will be securely tied together. A stronger panel is formed if the logs are tree nailed or otherwise fastened together as previously suggested. If short logs are used to build up the panels, considerable care and extra labor are required to bring the tops of the panels to the same height and to preserve uniformity of texture of the wall surface.

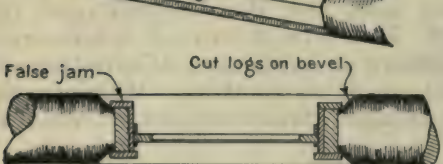


FIGURE 15.—Method of cutting logs for windows

INTERIOR FINISH

At best, much of the chinking has to be gone over during the second season, especially if the joints are wide. For this reason it is advisable to defer the interior trimming until after settlement or shrinking has ceased. The method of finishing is a matter of personal preference. Rustic interiors with balconies, knee-braced posts, etc., are more suitable for recreation shelters than for farm dwellings. Sometimes the inside faces of the logs are left rounded, but when smooth interior walls are desired the inner face of the logs, as they are laid, should be hewn to a perpendicular line. Frequently dwellings are sheathed inside with tongue-and-groove lumber, and occasionally they are plastered.

Partitions may be of logs placed vertically, laid horizontally to intermember with the outside walls, or built of 2 by 4 inch sawed studs and covered as in ordinary house construction. Cheap partitions are made of poles, of two layers of slabs with the rounded faces exposed and staggered so as to cover cracks in each layer (fig. 16), or of wide boards with 1 by 2 inch battens on both sides to cover the cracks. Stairs can be made in the usual manner or as illustrated in Figure 16. Poles and slabs are sometimes used for the carriages and treads in building stairs, but plank treads as shown in Figure 3 are the more usual.

FLOORS

A good tongue-and-groove floor is recommended for all log dwellings. The floors of minor farm structures may be of clay and sand rammed hard, or of logs laid on the ground with the top surfaces hewn flat. Tongue-and-groove flooring may be laid on joists of logs spaced 2 feet or on joists of dimensioned lumber spaced 16 inches. Joist logs spaced 2 feet should be 6 inches in diameter for 12-foot spans, 8 inches for 16-foot spans, and 9 or 10 inches for 20-foot spans, and should have the upper face flattened to make an even surface for flooring. If dimensioned timbers 2 inches thick, spaced 16 inches, are used for joists, their depth should be 2 inches greater than the diameters given for logs of the different spans, unless they are of light, weak wood, in which case their depth should be 4 inches greater than the diameters given for joist logs. Sometimes joist logs are cambered in the center to compensate for sagging in which case about 2 inches should be allowed for 20-foot spans. Long spans should be avoided if possible because of vibration and the difficulty of allowing for sagging.

It is advisable to use seasoned or sound dead logs for joists, partition studs, stairs, etc. as seasoned wood is not so subject to checking and warping as is green timber. The joists should be framed into the sill logs before the wall logs above the floor level are laid. One method of doing this is shown in Figure 17, A, but this type of joint requires considerable skill and labor. Another and more usual method, in the less-pretentious houses, is to run the joists entirely through the walls (fig. 2) if there is a second story; this practice ties the walls together at the second story. When dimensioned lumber is used for joists the framing may be as shown in Figure 17, B.

ROOF

A gable roof is best suited to log construction. The ridge should be at a height above the plate of from one-quarter to one-half of the span. The ridge can be kept straight and level more easily if a hewn or sawed 2-by-6-inch ridge board is used rather than a log, as such construction permits of rafters of uniform length and assures good alignment. (Fig. 18, A.) Two methods of framing rafters to the side walls are shown in Figure 18, B and C. Poles 4 to 6 inches in diameter, depending upon the span, will serve for rafters. (Fig. 3.) Slabs can be used for sheathing by placing the sawed sides up and fitting the rounded sides to the rafters so as to secure a fairly smooth surface. If the sheathing is to be covered with composition roofing, the edges of the slabs should be trimmed so as to form tight joints;

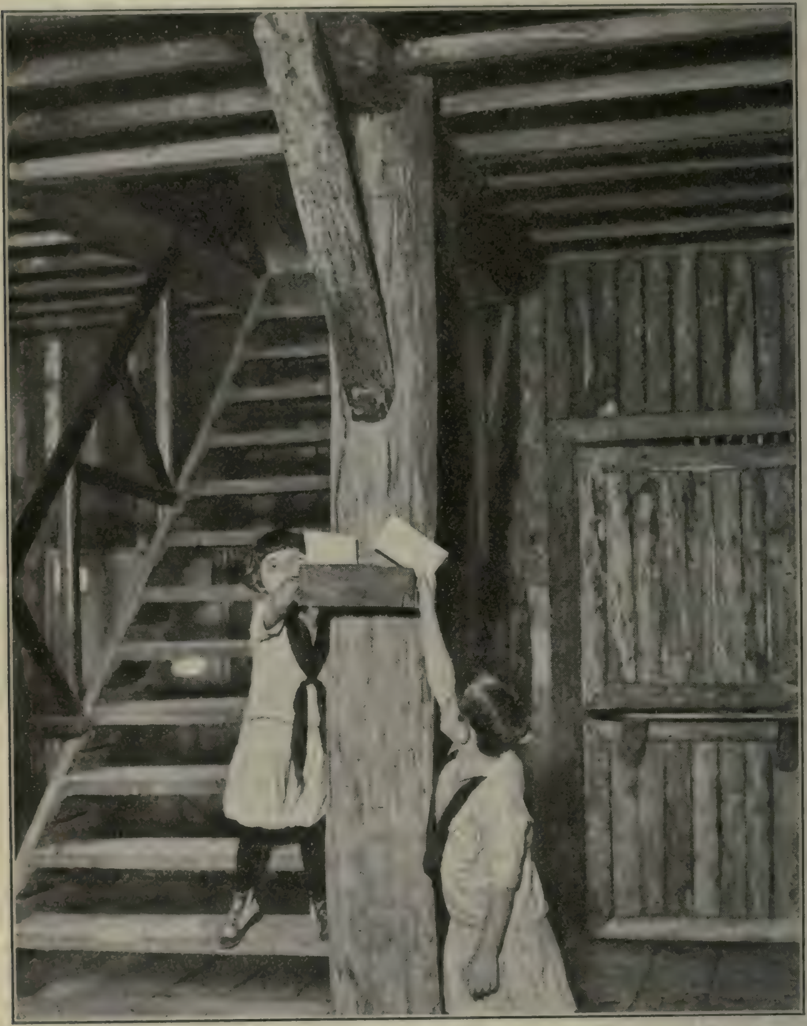


FIGURE 16.—An interesting method of framing a rustic partition; the Dutch door is unusual while the method of knee-bracing girders of long span is clearly shown

but if the roofing is to be of wood shingles the slabs can be laid with small spaces between them, or 1 by 4 inch sawed strips spaced 6 inches on centers can be substituted.

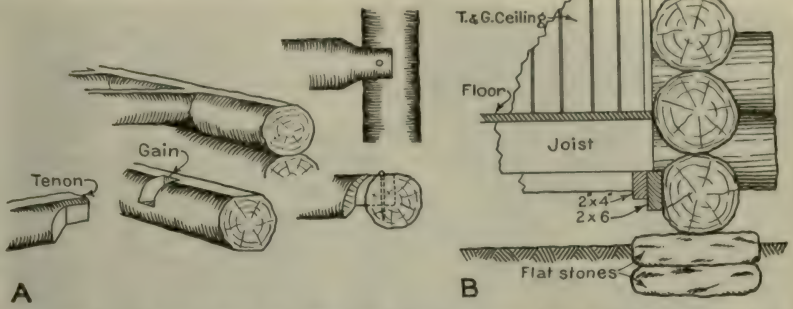


FIGURE 17.—A, a difficult yet very rigid joint between joist and sill; B, the floor level should be in line with the face of the wall log so as to form a tight joint

Sometimes poles are placed horizontally for the roof framing and membered with gable walls. Slabs or sawed sheathing may then be used as a base for the roofing, or if care is taken to place poles of uniform diameter fairly close together, the shingles can be laid without sheathing. (Fig. 19.) Shingles harmonize with log construction and should last from 10 to 15 years or longer if they are of good cedar or white pine. Spruce or hemlock shingles will also serve, but they are not as durable. To avoid leakage, all ridges, valleys, and hips should be covered before the shingles are laid, with strips of painted tin 16 inches wide. Chimneys or other projections through the roof should be flashed with the same material. Occasionally the roof is covered with two layers of slabs placed face to face (fig. 20) and laid so as to break joints, but such a roof is likely to leak if the slabs warp or open up, and this construction is suitable for only very temporary structures. Of course, other coverings besides shingles—such as tarred roofing, composition shingles, and corrugated sheet metal—can be used to advantage but at a sacrifice of appearance.

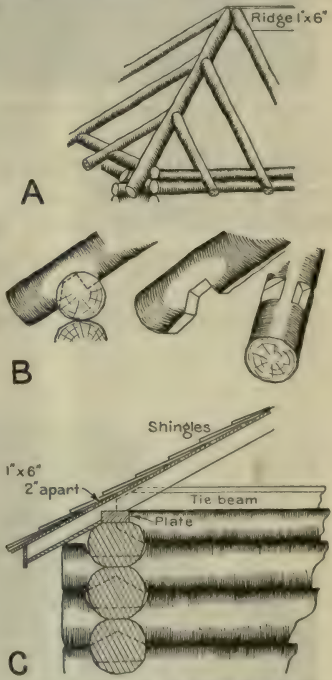


FIGURE 18.—A, a ridge board facilitates making a straight roof line; note that the hip rafters are larger than the common rafters; B, with this type of joint it is difficult to keep the eaves level; C, a good method of terminating the wall even though poles are used for rafter

CHIMNEYS

Farmers' Bulletin 1649, Construction of Chimneys and Fireplaces, contains directions for building fireplaces and safe chimneys. In planning the structure, consideration should be given to the location of the chimney for if built into an interior wall openings can be provided for stovepipes from the various rooms, thus permitting the individual rooms to be heated. The chimney should be well built, especially if the log house is to be a home. Two or more flues can be built in the same chimney. The fireplace should be connected to a separate flue which should be not smaller than 8 by 12 inches; flues for the stoves should be not less than 8 by 8 inches. Because of the protection from fire which they afford, all flues should have terra-cotta linings. The log chimney (fig. 21) while picturesque is a fire menace

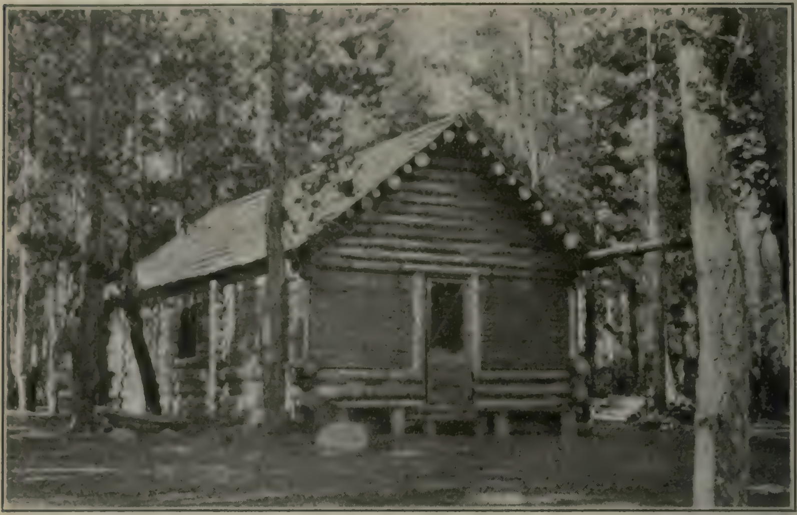


FIGURE 19.—Large shingles are placed directly on logs which alternate butt and point, no sheathing being used

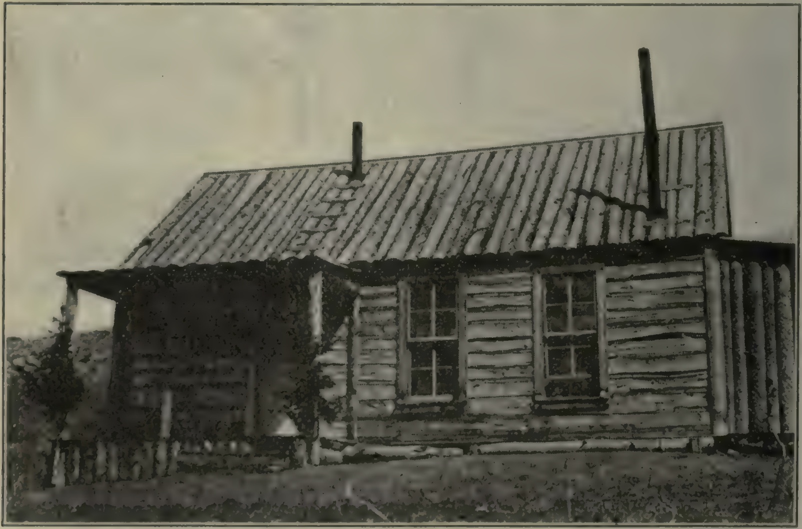


FIGURE 20.—Two layers of slabs placed with sawed faces in contact are unsatisfactory for a permanent roof and if used the roof pitch should be fairly steep

and should be used only as a veneer for a properly built masonry stack. A chimney should be built on a foundation resting on solid ground and never on a shelf. The expense of the extra masonry is well warranted and is a good investment. A good draft can not be assured unless the chimney is at least 20 feet high.

Rubble masonry [3] is considered very desirable for use in building the exposed parts of fireplaces (fig. 22) and the chimney proper because it blends with the rustic character of log construction better than brick or concrete. While masonry chimneys should always be used when practicable, there are times when expediency warrants the extension of a stovepipe through the roof. (Figs. 8 and 20.) When this is the case a hole 18 to 24 inches square should be cut through the roof and covered, on top of, and underneath the rafters, with sheet metal having a hole at the center equal to the diameter of the pipe.

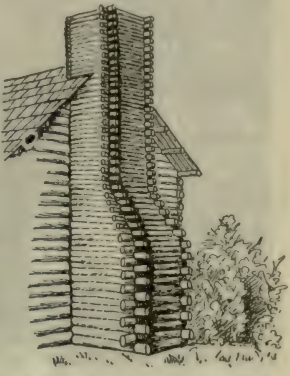


FIGURE 21.—A dangerous type of chimney

PORCHES

Wide porches add considerable comfort to a house in the country as they can be used for work, rest, and entertaining throughout much of the year. The extra space thus provided costs less than like space incorporated in the house proper. Figure 23 shows how easily a porch can be obtained, while Figure 1 shows how extra room can be cheaply provided between the wings or sections of a house.

CONVENIENCES

Water and plumbing systems are essential features of modern homes. The fixtures need not be elaborate nor costly. Some of the simpler systems [4] can be installed with a few tools.

COST

Very little information is available relative to the cost of log construction, but whether the builder of a log house be wealthy or poor he will find it economical to hire woodsmen rather than carpenters to hew and handle the heavy logs. Men of considerable experience with house construction are sometimes amazed at the high cost of log houses erected by workmen who, though skilled in ordinary house building, are unfamiliar with the technique of log construction. On the other hand, many pioneers built homes of logs at small cost which stood long enough to serve several generations. It is the usual experience of those who build their first log house with hired help that the amount and cost of labor necessary is somewhat greater than would have been required if dimensioned lumber had been used. The builder of the house shown in Figure 4 estimated that, even though the logs were cut on the site, the walls cost 50 per cent more than they would have cost had he used 2 by 4 inch stud

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[3] Instructions for the use of field stones in rubble masonry can be had from the Bureau of Agricultural Engineering, Washington, D. C.

[4] See Farmers' Bulletin 1227, Sewage and Sewerage of Farm Homes; Farmers' Bulletin 1426, Farm Plumbing; Farmers' Bulletin 1448, Farmstead Water Supply.

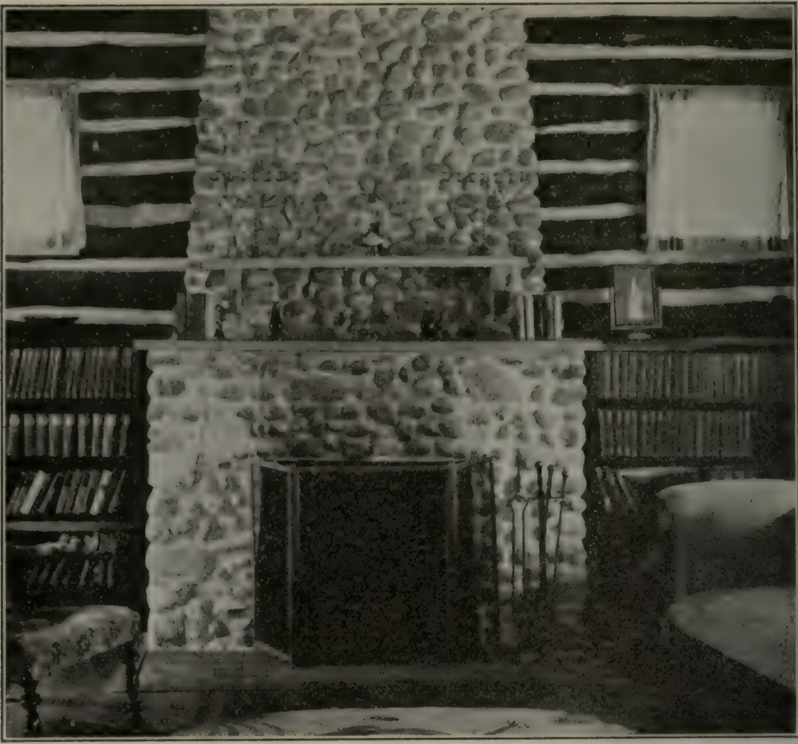

FIGURE 22.—A well-built stone chimney, exterior shown in Figure 4. The exposed logs make a very pleasing interior

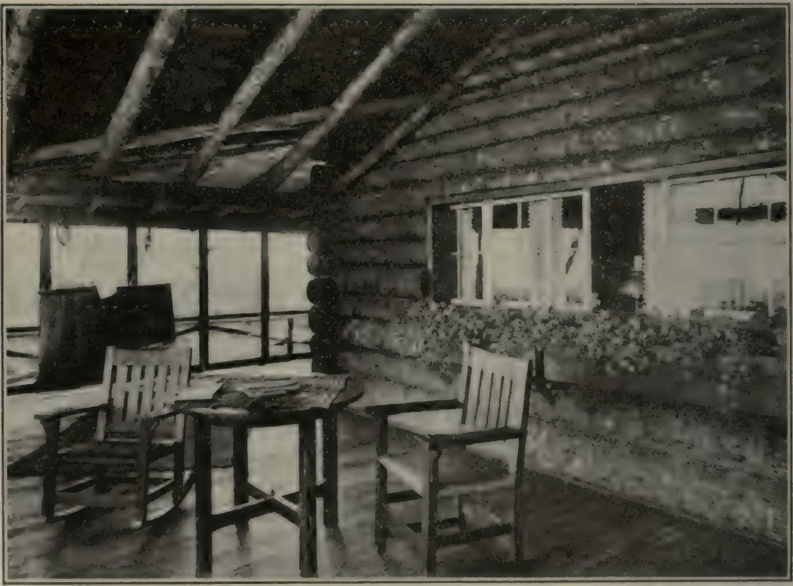

FIGURE 23.—A wide porch

walls. However, he was put to extra expense for scrubbing the logs with wet sand to remove blue mold or mildew that formed upon them, and he was very careful in executing all details.

OTHER USES OF LOGS

The principles outlined for the construction of log houses can readily be applied to the building of other types of farm structures and equipment. A serviceable barn can be had by covering a pole frame with slabs. (Fig. 24.) While the roof may be entirely of slabs, as shown, it is best to use only one layer with the sawed faces up to serve as sheathing for prepared roofing or other covering. The slabs should be trimmed at the edges to permit their being laid close together.

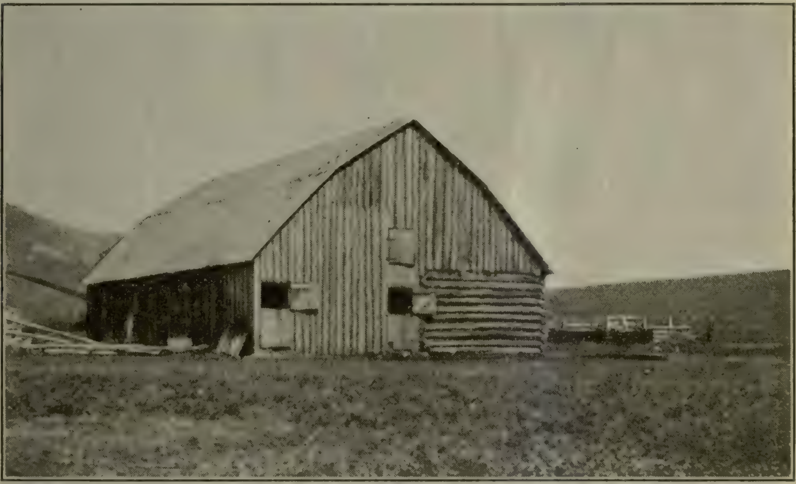

FIGURE 24.—Particular emphasis is made here on the necessity of ample light since too frequently barns, especially when built of logs, do not have a sufficient number of windows to assure a healthful interior for stock

Pole construction may be employed in the erection of buildings for various other purposes. An excellent example of such construction is shown in Figure 25.

Logs are used extensively for building culverts (fig. 26), bridges (fig. 27), causeways (fig. 28), and cattle cross unders beneath highways (fig. 29). Such structures should be built of durable species. Figure 30 illustrates a convenient table with benches attached, suitable for outdoor use. Figure 31 shows a good method of protecting haystacks in the field, while an easily built hay feed rack is illustrated in Figure 32.

Poles of 2-inch diameter can be used for ornamental paneled fences, stock pens, gates, and stiles (see footnote 4, p. 19), or for light and easily built fences such as shown in Figure 33.

Logs 8 inches or larger in diameter can be used for the superstructure of an ice house and, if it is partly below ground, for lining the pit when the soil will not stand without support. If the walls are of heavy logs and they are well chinked, no insulation should be required other than the 2 feet of sawdust for packing between the

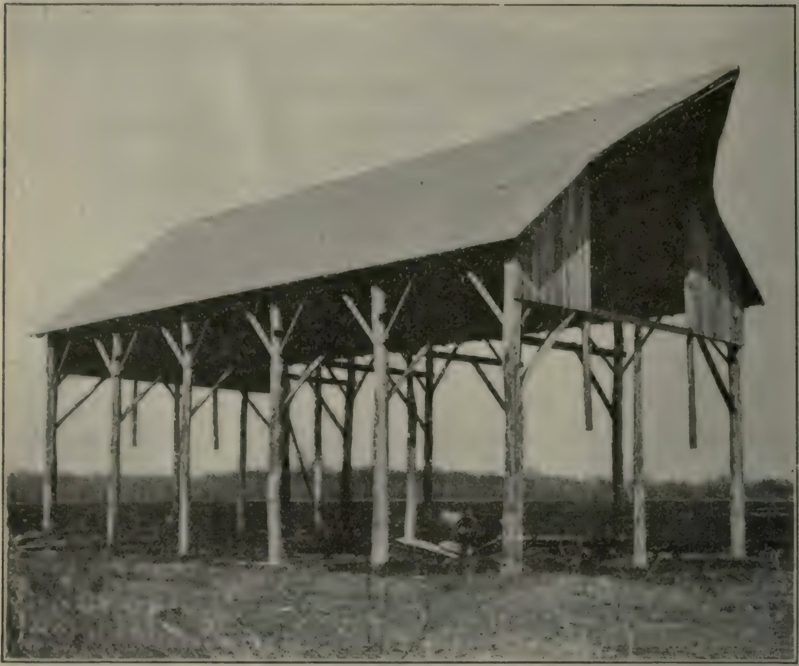

FIGURE 25.—Hay shed 24 by 60 feet; posts are 12-inch logs 25 feet long. The roof could well be of slabs and these could be used to close-in the sides. Knee braces of 5-inch and girders of 10-inch diameter logs could be used instead of the dimensioned lumber

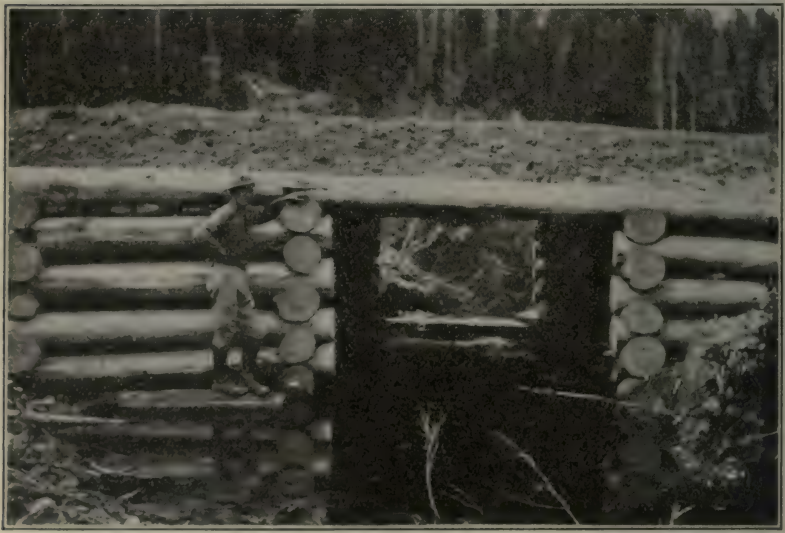

FIGURE 26.—A 10 by 6 foot log culvert. The span and height can be varied to suit local needs

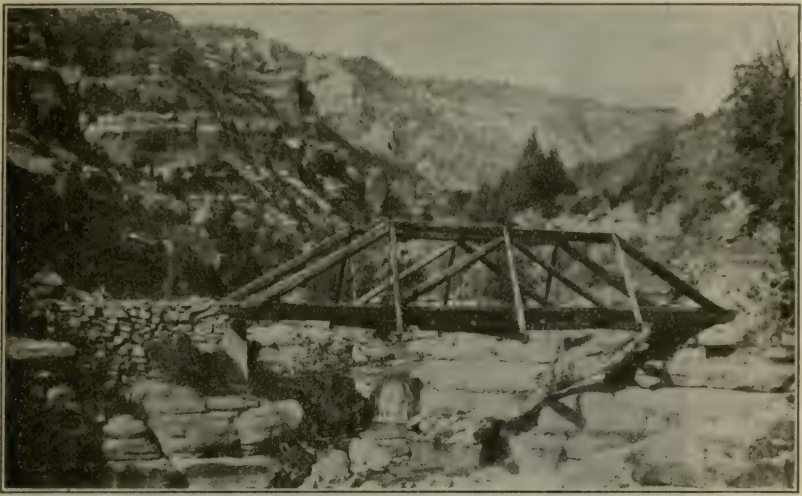

FIGURE 27.—A log bridge of 40-foot span. Such a structure can not be built by an amateur

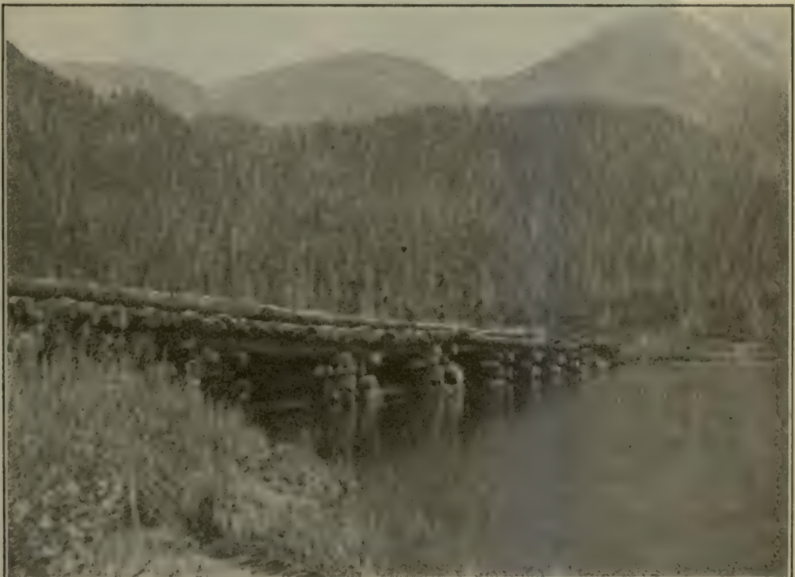

FIGURE 28.—Bridge suitable for crossing a swamp or shallow stream. The piers, 20 to 30 feet apart, are built up of cribbed logs

inside wall surface and the ice. Logs of a durable species should be selected for this use. Poles of smaller diameter placed vertically can be used for a temporary ice house.

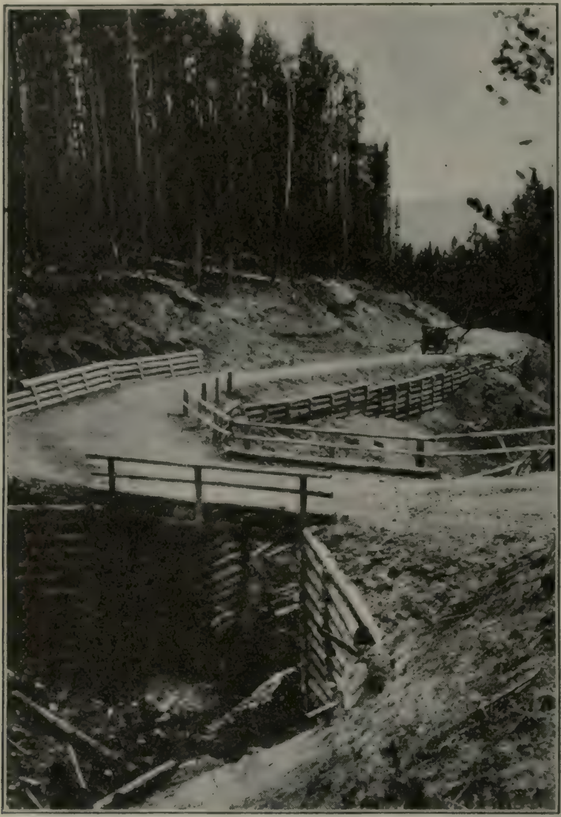

FIGURE 29.—Method of constructing culvert-bridge spans of 12 to 20 feet. The cribbed buttresses reduce the span and form secure rests for the bridge. Cross unders to enable cattle to pass between fields each side of the road can be built in this manner. Note the method of protecting the road from erosion

The Department of Agriculture has published a number of bulletins and prepared several drawings describing the use of logs for various purposes. These are listed below:

Farmers Bulletin 847. Potato Storage and Storage Houses; describes in detail a cellar of logs and gives the requirements for storing potatoes.

Farmers' Bulletin 1738, Farmhouse Plans, contains plans for one house of logs and for other houses that could easily be adapted to log construction.

Department of Agriculture Yearbook Separate 1036, Road-Work on Farm Outlets Needs Skill and Right Equipment; Figure 201 shows a typical design of a split-log road drag.

Farmers' Bulletin 1487, Practical Hog Houses; Figure 9 shows a hog shelter of logs and brush.

Drawings Nos. 1247, 1625, and 2086 illustrate logrollers, floodgates, and a haystacker, respectively. Blue prints of these designs and instructions for using wooden fence posts may be had from the Bureau of Agricultural Engineering, Washington, D. C.

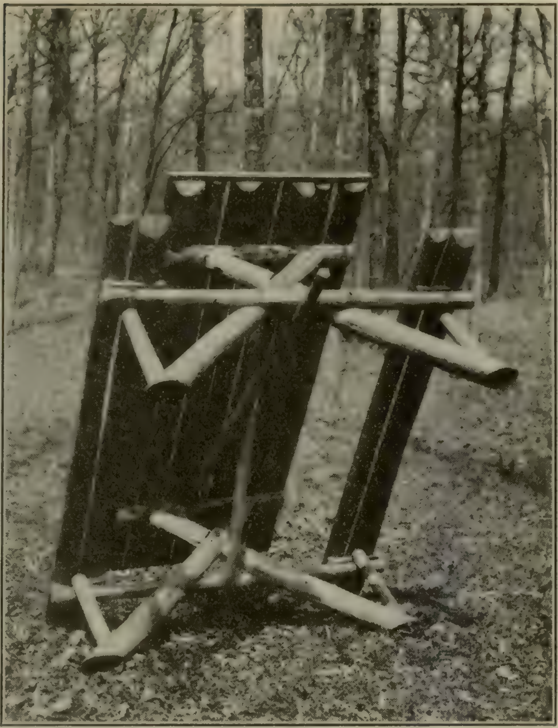

FIGURE 30.—A convenient type of table, tipped to show its construction. Note that the tops of the logs of the table and the benches are hewn flat

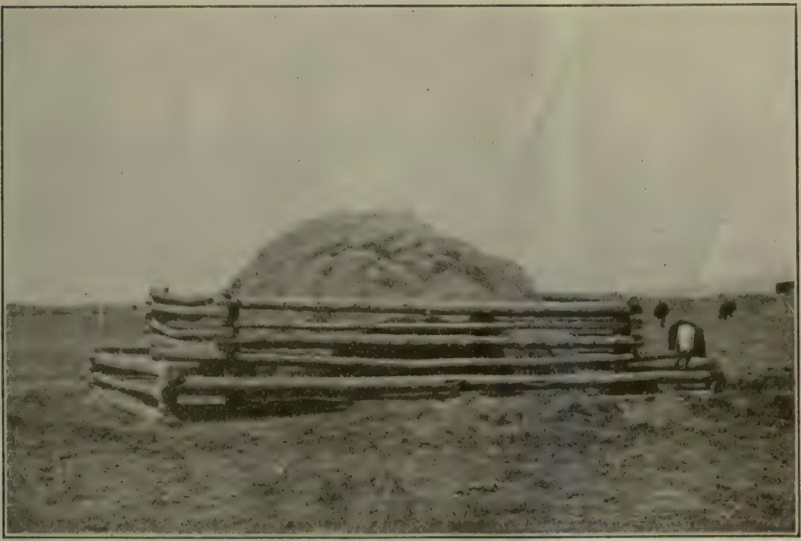

FIGURE 31.—Method of protecting stacks from cattle; note the feed troughs on two sides

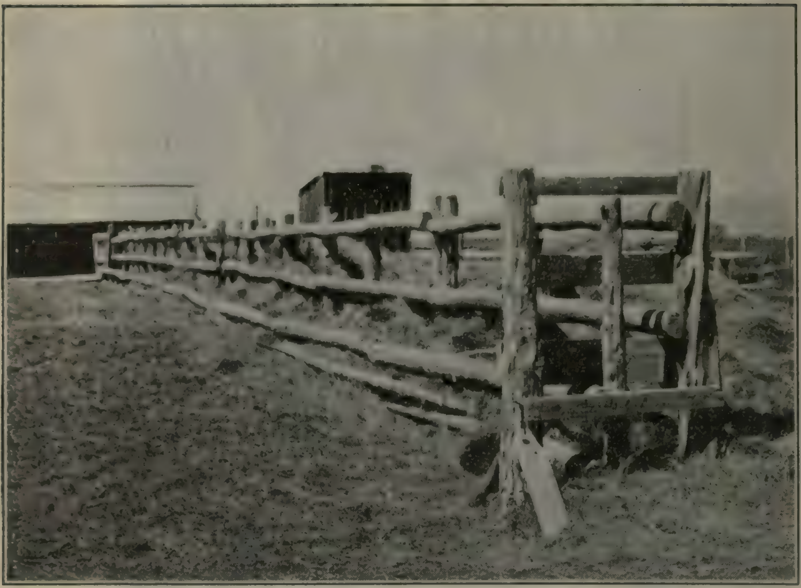

Figure 32.—A feed-lot hay rack, rather wasteful of hay, but more economical than feeding from the stack and suitable for temporary use

Figure 33.—A supports of 3-inch poles, 8 to 10 feet apart, stuck in the ground 18 inches and nailed or wired at the apex. The top rail, a 1½ to 2 inch pole, is fastened in the crotch and the bottom rail is nailed to the frame. Three or four rails could be used, depending upon the desired tightness of the fence

U. S. GOVERNMENT PRINTING OFFICE: 1935

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - Price 5 cents

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1661

FARM STUDY OF THE COTTON PLANT

A FAIR KNOWLEDGE of the cotton plant is essential to the grower, not only from the standpoint of enabling him to care better for his crop and to utilize improved methods and varieties but also because of the fact that knowledge of the plants and their life functions tends to arouse a new and higher interest in farming. Such knowledge should enable the grower to see and appreciate the value of improved varieties, cultural methods, and systems of production.

By growing only one type of cotton regularly the farmer becomes more familiar with the habits of the plants and knows how they will behave under certain conditions. With a good understanding of the behavior of the plants, the grower is able to rogue out the off-type plants from fields that are to furnish planting seed, and not only has more interest and satisfaction in growing his crop properly but also receives a better return for his labor.

This bulletin describes the principal parts of the cotton plant and the growth habits and functions of each. The different parts are easily distinguishable and may be learned with little effort by considering each part as a separate unit and by thinking of the different units by name.

Washington, D. C. **Issued March, 1931**

FARM STUDY OF THE COTTON PLANT

By J. W. HUBBARD, *Senior Scientific Aide, Office of Cotton, Rubber, and Other Tropical Plants, Bureau of Plant Industry*

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INTRODUCTION

THE EFFORTS to avoid the depredations of the boll weevil have led to many valuable and interesting discoveries regarding the characters and habits of the cotton plant, as affecting its ability to produce good crops under weevil conditions. The selection of new varieties and the development of improved cultural methods are based on the knowledge of the habits of growth and development of the plant, and the principal features of the plant structure must be understood by the grower before a full utilization of such discoveries or improvements can be expected.

Without understanding the behavior of the plants, there is no practical means whereby one may judge the merits of a variety or method or make the tests or comparisons that may be necessary to determine differences of behavior under local conditions. Hence it appears that the farmer should have a fair knowledge of the principal parts of the cotton plant, together with their habits of growth and functions. Every farmer should at least know the type of cotton he is growing and be able to rogue out the off-type plants from fields that are to furnish planting seed. Farmers who are continually changing from one variety to another usually do not become familiar with the true characters of any of the varieties and are not able to detect the off-type or aberrant forms so readily as do farmers of 1-variety communities.

COMPARATIVE DIFFERENCES

Plants are like animals in being composed of many structural units which possess distinctive characters so that the different features can be observed and compared in detail, but most people have not learned to discriminate so closely among plant varieties as among breeds of animals. It is much easier to learn the distinctive characters of animals than of plants, because the visible parts of the animal's body are directly comparable to those of the human body. With the plants there are no parts that are commonly recognized as comparable to parts of the human body, and consequently the plant more often is looked upon as a whole, without considering the particular features. In order to know and understand a plant, the structure and arrangement of its principal parts must be learned, for the foundation of knowledge of any object lies in an understanding of its component parts.

In studying the cotton plant two principal kinds of differences are encountered. The structural parts, such as branches, leaves, or fruit, may differ in themselves, or differences may be found in the number and arrangement of parts which otherwise are alike. The habits of branching include many features of practical importance to the farmer, both in relation to varieties and to cultural control.

TWO KINDS OF BRANCHES

The main stalk of the cotton plant consists of a series of nodes and internodes. The nodes are the joints where the leaves and branches are attached, and the internodes are the sections between the nodes. A leaf develops at each node, and at the base of each leaf are two small buds. The bud just above the axil of the leaf is called the axillary bud, and the one to the right or left is called the lateral or extra-axillary bud. As a rule the true axillary buds produce only vegetative branches, or " wood limbs," which function as secondary stalks. The extra-axillary buds are readily capable of producing either vegetative branches similar to those of the axillary buds, or the fruiting branches that bear the flowers and fruit. Usually only one of the buds develops at each node, the other remaining dormant, but in some varieties two branches are often produced from the same node. (Fig. 1.)

The leaves of the stalk are arranged in a spiral, and the right-hand or left-hand position of the fruiting branches is determined by the direction of the spiral and is regular for each plant. Some plants are right-handed and others left-handed with respect to the position of the branches.

Fruiting branches differ from the vegetative branches in that they are usually very much smaller, their positions are more nearly horizontal, and they produce a floral bud, or square, at each node. Also each fruiting-branch joint diverges from the direction of the preceding joint, forming a zigzag structure that often shows a strong contrast with the straight, round, stalklike vegetative limbs.

The positions on the main stalk of the two kinds of branches are also different and quite regular. As a rule, the vegetative branches occupy a definite zone near the base of the plant, while the fruiting branches begin farther up the stalk and occur regularly at each node. The number of nodes from the base of the main stalk to the lowest fruiting branch is not a constant character and varies considerably in different kinds of cotton and under different conditions of growth. In some cases the first fruiting branch may appear as low as the fifth or sixth node, while in others there may be twice as many nodes below the first fruiting branch. If vegetative branches do not develop, the lower nodes of the stalk usually remain vacant.

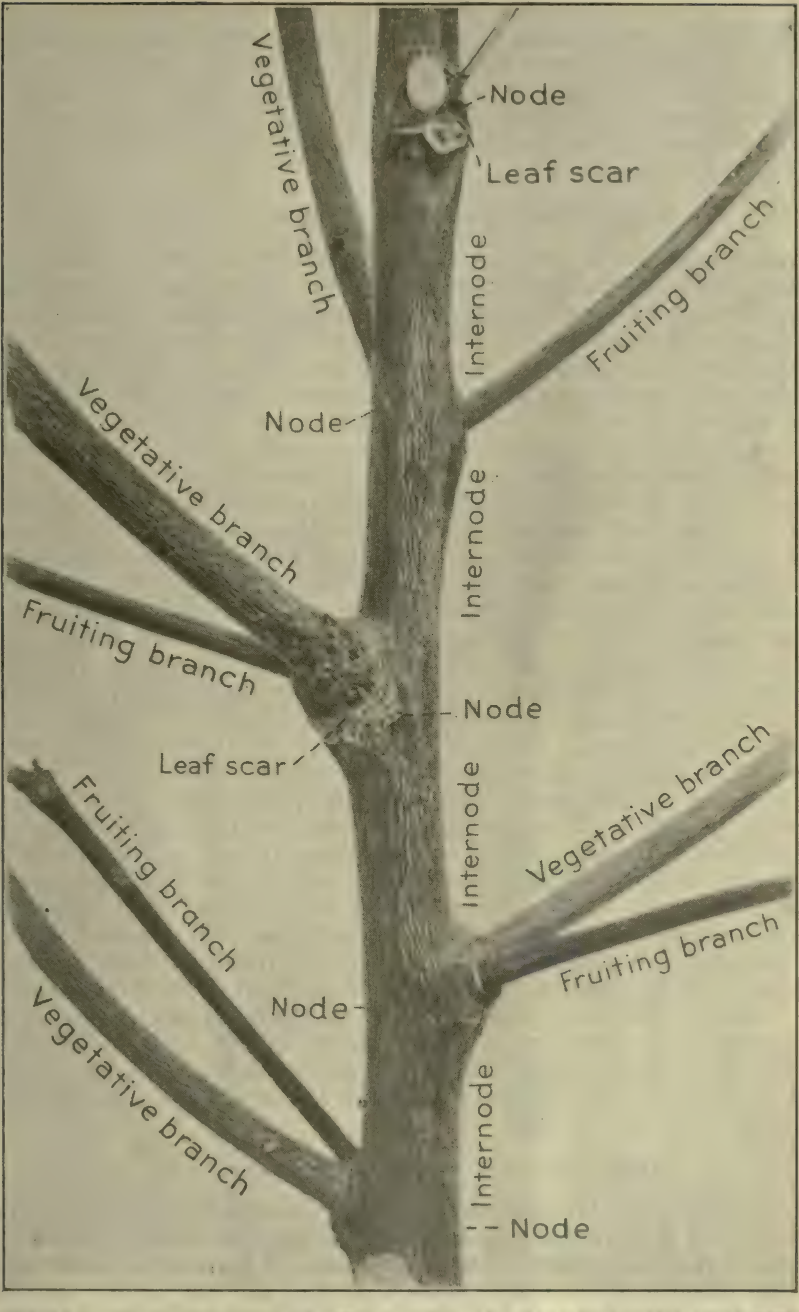

FIGURE 1.—Double branching, showing a section of a Lone Star cotton plant with a vegetative branch and a fruiting branch at four consecutive nodes. A leaf scar is shown at the upper node where the branch has been cut off; it shows the positions of the branches in relation to the leaves of the main stalk. The fruiting branch shown at the lower node was lifted above the vegetative branch to show its attachment at the node. (Nearly natural size)

The vegetative branches, developing from near the base of the stalk, usually have an upright position and often grow as tall as the main stalk, or even taller. Their function is practically the same as that of the main stalk, with an axillary and an extra-axillary bud produced at each node, from which the two kinds of branches are developed. (Fig. 2.) No flowers or fruit are produced directly on vegetative branches.

VEGETATIVE BRANCHES NOT DESIRABLE

Under boll-weevil conditions it is especially desirable to have the plants produce fruit rapidly and as early in the season as practicable. This is accomplished through closer spacing of the plants in the rows, since during the early flowering period a large number of these small plants produce more flowers and set more bolls than a smaller number of large plants occupying the same space in the rows. In some seasons it happens that a large proportion of the crop is set on the lower fruiting branches of the main stalk during the first two or three weeks after the plants begin to fruit, before any bolls can be set on the secondary fruiting branches produced by the vegetative branches, or "side stalks," as they sometimes are called. In such cases the yields have been found to depend more upon the number of plants per acre than upon the size of the plants. If the season is sufficiently long and no serious damages from insect pests are encountered, a smaller number of wide-spaced plants with large vegetative branches may yield as well as a larger number of small plants without vegetative branches. But where it is desired to produce the biggest crop in the shortest time, larger yields are obtained with more plants per acre. Plants with vegetative branches are not desirable and should be avoided by closer spacing.

The term "single stalk" is applied to plants that produce only fruiting branches. Plants that are spaced less than 1 foot apart in the row, or left in hills of two or more plants together, with the hills from 8 to 20 inches apart, usually do not produce any vegetative branches, or have only a slight growth of such branches, instead of the numerous "side stalks" of large rank-growing plants.

Closer spacing is being used more and more by the best growers, and most of the contests for larger yields have been won through this method. In many cases the seeds are planted at the rate of 20 to 25 pounds to the acre, and the stand is left unthinned. This method of leaving the cotton unthinned seems particularly adaptable to districts where seasons are short and the plants do not grow too rank.

DEVELOPMENT OF FRUITING BRANCHES

The manner of development of the fruiting branch is somewhat peculiar, in that the first part of the branch to become visible is the floral bud, or square, of the first node. As the branch develops the internode gradually lengthens, carrying the young bud and its leaf away from the stalk, as shown in Figure 3. The leaf at first is smaller than the square and grows rather slowly, usually unfolding from four to seven days after the square becomes visible. The floral bud of the next node appears in the axil of this leaf, usually at about the time the leaf unfolds, and later is carried away from this

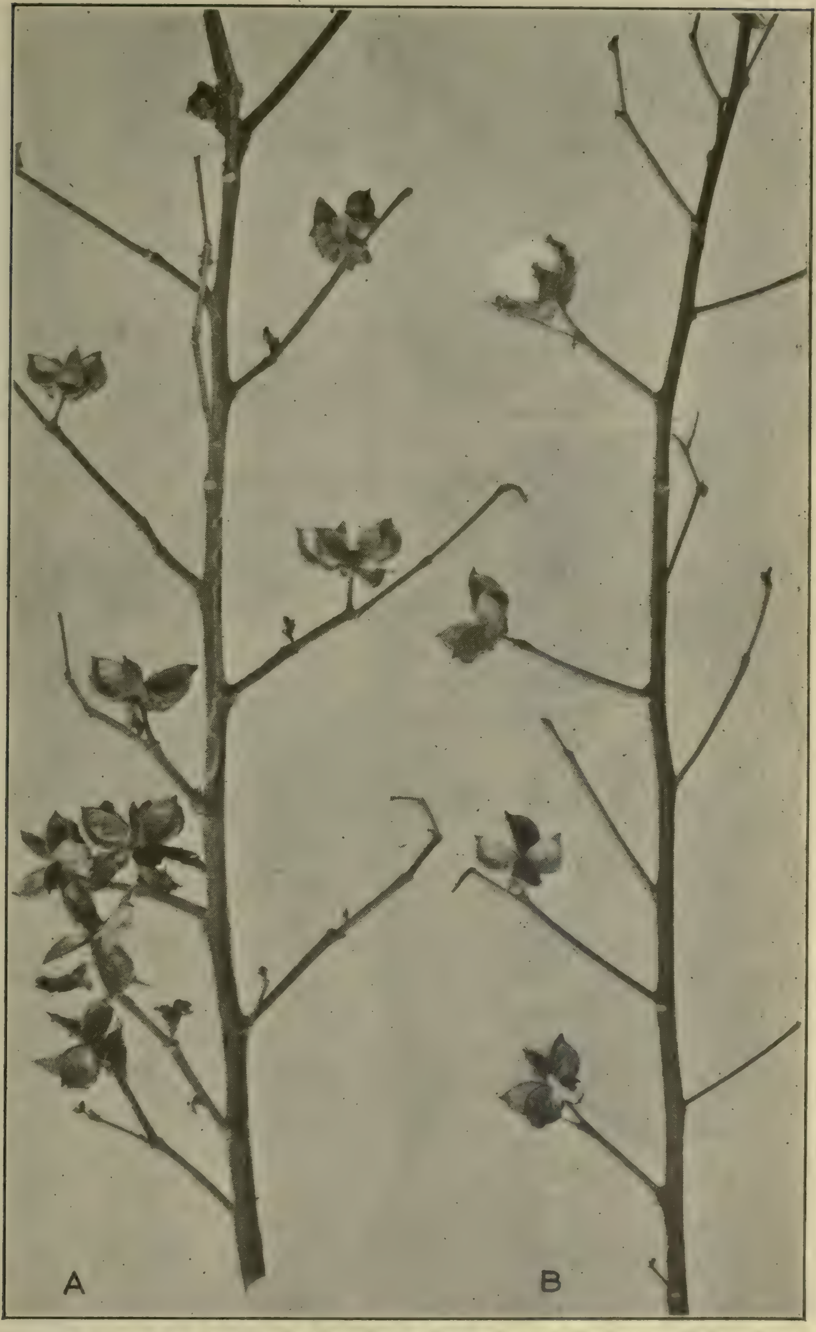

FIGURE 2.—Main stalk (A) and vegetative branch (B), both with fruiting branches showing section of a large vegetative branch in comparison with section of main stalk of the same plant

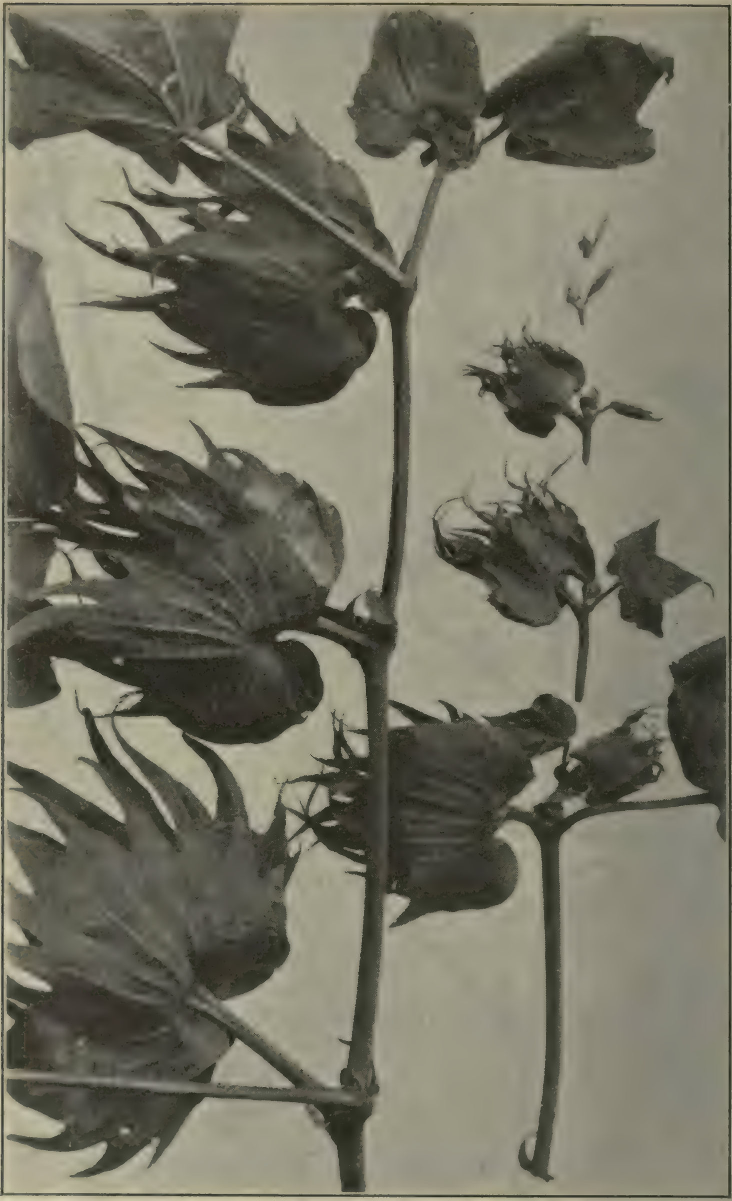

FIGURE 3.—Development of the cotton fruiting branch. It becomes visible at the stage represented by the very small square and folded leaf at the upper right. As the square and leaf grow, the supporting internode lengthens, carrying them away from the stalk. This square and leaf occupy the first joint of the fruiting branch. About the time that the first fruiting-branch leaf begins to unfold, another small square and folded leaf becomes perceptible in the axil of the first leaf, as shown in the third branch from the top. This second square and leaf occupy the second node of the fruiting branch and are carried away from the axil of the first leaf by a subsequent lengthening of the second internode. This process of development is repeated in successive joints of the fruiting branch, as shown at the left. Note the alternating positions of the floral bud at the nodes of the fruiting branch. (Nearly natural size)

position by the growth of the second internode. This procedure is followed throughout the development of the fruiting branch, the new floral buds usually appearing at intervals of from five to seven days. Thus it is seen that the floral buds or squares are formed as the branch develops, a bud at each node.

Under favorable warm-weather conditions the first fruiting branch usually appears from 20 to 30 days after planting, but more time is required during the early spring, as germination may be delayed and growth retarded by cool weather. Fruiting branches usually appear at successive nodes of the main stalk at 2-day to 3-day intervals, or about twice as fast as squares are formed on consecutive nodes of the fruiting branches. Thus a more rapid setting of fruit early in the season is made possible by having larger numbers of plants in the fields, as in the single-stalk system of close spacing, than with smaller numbers of larger wide-spaced plants that produce a part of their crop on secondary branches from the vegetative limbs.

DEVELOPMENT OF SQUARES AND BOLLS

The period of development from the appearance of a square or floral bud until the bloom opens has been studied in several varieties of upland cotton and found to be practically the same, the average period ranging between 25 to 30 days. Likewise, the period from flower to open boll has been determined and found to be nearly the same among the upland varieties. The time required is usually between 35 to 45 days, but it depends to a great extent on seasonal conditions. Late-season bolls often require from 10 to 20 days longer to open than bolls of the same plant produced earlier in the season. Thus the periods of square development and of the growth and opening of the bolls apparently are not of first-rank importance as factors of earliness. Other factors now recognized are rapid early growth, development of fruiting branches from lower nodes of the main stalk, and retention of the squares and bolls produced early in the season.

DANGER OF MISJUDGING EARLINESS OF VARIETIES

Some varieties of cotton have more determinate habits of growth than others; that is, they stop growing more promptly after a few bolls have been set, especially if dry weather is encountered. Such varieties may open all their bolls before frost and give an impression of being very early. Other varieties may set fruit as promptly at the beginning of the season, but continue to grow and produce bolls for a longer period. Some of the late-season bolls of a continued-fruiting variety may not open until frost, so that the variety appears to be late, even though a larger crop of bolls may have matured than in the type that seemed to be early. Such differences of fruiting habits have been shown in careful side-by-side comparisons of different varieties. Varieties should not be considered late merely because they continue to grow and produce a top crop which may be caught by the frost, but should be judged on the amount of seed cotton matured before frost. Such determinations should be made from the actual picking weights of carefully conducted side-by-side comparisons, as the appearance in the field is often deceiving.

THE INVOLUCRE

The floral bud of the cotton plant has an outer envelope, termed in botany an involucre, which is formed of three small leaves, or bracts, set close together in a triangle with the bud in the center. The involucre may be considered as replacing the calyx, which in the cotton plant is very small and covers the bud only in the early stages. No doubt the primary function of the involucre is to cover the young buds, though such protection apparently is not necessary under the usual cultural conditions and may even have disadvantages. The involucre often is a hiding place and point of attack for boll weevils, bollworms, mildews, anthracnose, and other pests and diseases that destroy many of the buds and bolls. Another disadvantage of the involucre is that much of the "trash" which lowers the commercial grade of the cotton consists of broken bract material. In varieties with large involucres more of the bract material is picked with the cotton and becomes entangled with the fiber during ginning.

The breeding of cotton varieties with smaller involucres is worth considering, not only to make poisoning easier and reduce the losses caused by weevils and other insect pests but also at the same time to improve the grade of fiber by reducing the amount of trash. The Acala cotton has smaller bracts than most varieties of the Texas big-boll series, and strains with still smaller involucres probably could be established through careful breeding work. Tropical types of cotton have been found with extremely small bracts which give very little shelter to insect pests and diseases.

HAIRY SURFACES OF COTTON PLANTS

The cotton plant has a covering of hairs on the surfaces of the leaves, bracts, and young stems. The extent of hairiness varies greatly in different species. In some species the hairs are very dense, giving the plants a grayish color and a soft surface texture similar to velvet. Other species have the hairs so sparse as not to be noticeable without close examination. Most of the hairs are not simple but are united in clusters and project in all directions from the point of attachment, forming stellate or star-shaped groups. These clusters of hairs make it difficult to separate completely the trash from the cotton fiber. Cleaning devices at the gins would readily remove even the small bits of dead leaves and bracts if they were smooth or had only simple hairs, but some of the fibers become so entangled in the stellate hairs that it is practically impossible to separate all of the trash particles from the fiber at the gin. The tangled fibers and the small bits of trash are either combed out as waste in the spinning operations or remain to cause blemishes in the finished mill product.

At present no type of cotton is known that is entirely devoid of hairs, though many variations exist in the nature and extent of hairiness. In some species most of the hairs are shed before the leaves have reached full size, while in others the hairs are very persistent, even on the old stems. A new species of cotton with simple hairs has been discovered recently in South America but is not adapted for cultivation in the United States.

The reduction or suppression of the stellate hairs is a character to be considered in breeding. The development of varieties with only simple hairs might be possible if the desirability of this character is recognized in the work of selection.

FLUCTUATING CHARACTERS OF LEAVES AND BOLLS

Some of the characters of cotton plants are regular and constant, while other characters are much more variable. Two examples of such differences which are present in all varieties of upland cotton and on practically every individual plant are the differences in the lobing of the leaves and in the number of locks in the bolls. It is a common mistake among those unfamiliar with the cotton plant to suppose that the presence of variously lobed leaves or of bolls with different numbers of locks, as 3-lock, 4-lock, or 5-lock bolls, is an indication of a mixed stock. These irregularities are normal and have no bearing upon the purity of the variety, though many other characters of the leaves and bolls are important in recognizing differences among the plants.

Apart from the number of locks, the shape of the boll is one of the most important characters to consider in selection, since it is usually associated with other distinctive characters. (Fig. 4.) Uniformity of fiber, which is one of the most important factors in determining the value of a variety of cotton, is evidenced by uniformity of boll shape, and the length of fiber also may be judged to a considerable extent from the shape of the boll. A round boll usually represents rather short fiber, and a long gradually pointed boll usually represents rather long fiber. As a general rule, the longer the boll the longer the fiber.

The storm-proof character also appears to be associated with the shape of the boll in the same manner as the length of the fiber. Most of the upland varieties having short, round bolls are characterized by short fiber that strings out of the bolls soon after opening. This fluffing and stringing out of the lint gives an impression of a larger yield in comparison with the storm-proof varieties, in which the lint remains in the boll in a compact mass. Storm proofness may be considered as an indication of good length and quality of fiber as well as protection from storm damage. Such relations might well be expected, since the length and quality of the fiber and the structure of the carpel are important factors in determining storm proofness.

Another boll character that usually is associated with the short, round forms is the "split-nose" or "harelip" deformity, represented by distinct grooves or splits between the carpels at the tip of the boll. These grooves, or open sutures, render the bolls much more susceptible to diseases and should be carefully avoided when making selections. (Fig. 5.)

SEED AND LINT CHARACTERS

The seeds of most varieties of cotton produce two distinct kinds of hairs—long hairs, represented by the lint fibers, and much shorter, finer hairs, commonly called "fuzz." In some varieties the fuzz fibers may be uniformly white like the lint, but in most cases the fuzz has a brown or greenish cast. The color and density of the

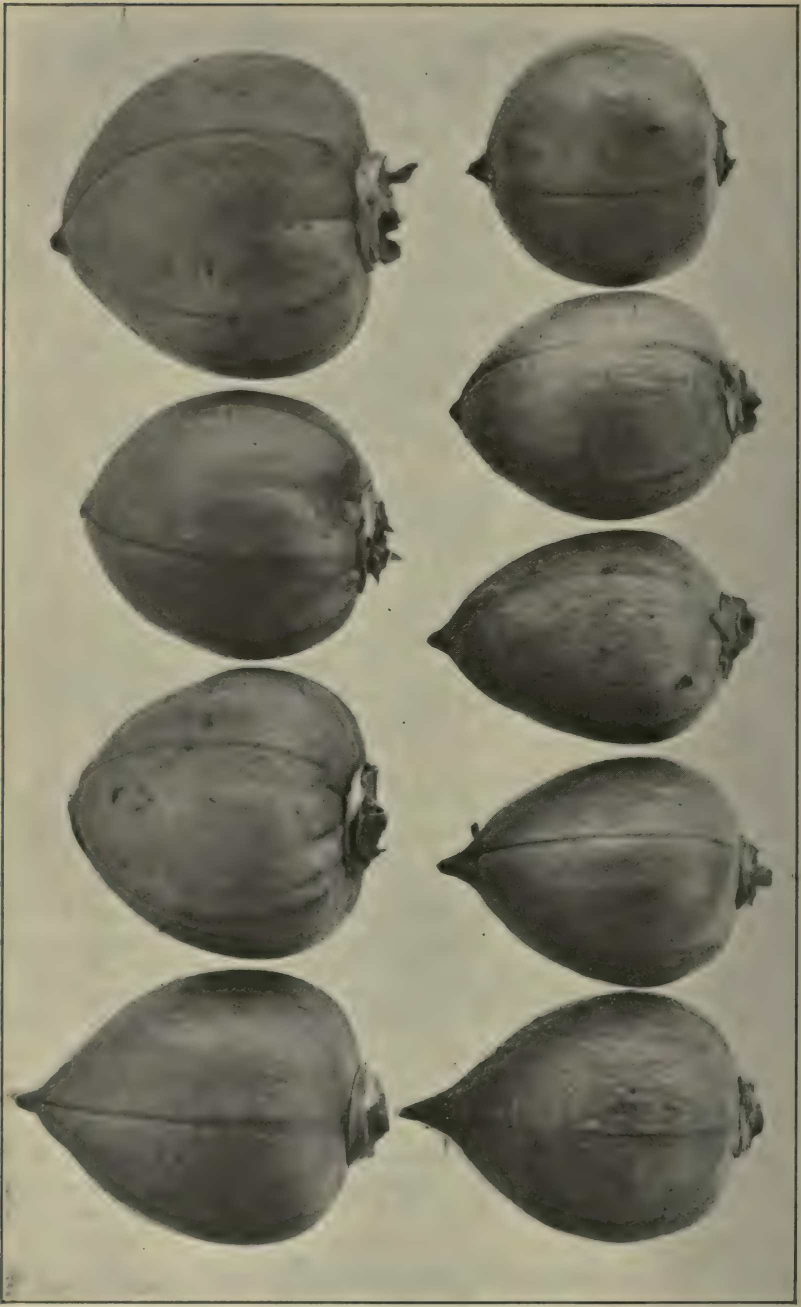

FIGURE 4.—Variations in the shape of mature, unopened bolls. Variations in the size of the bolls may be due to conditions and may have little bearing on the purity of the variety, but frequent variations in the shape of the bolls are a definite indication of mixing or neglect of selection. It is necessary to adhere strictly to a single-boll type in order to establish and maintain a uniform length and quality of staple. (Nearly natural size)

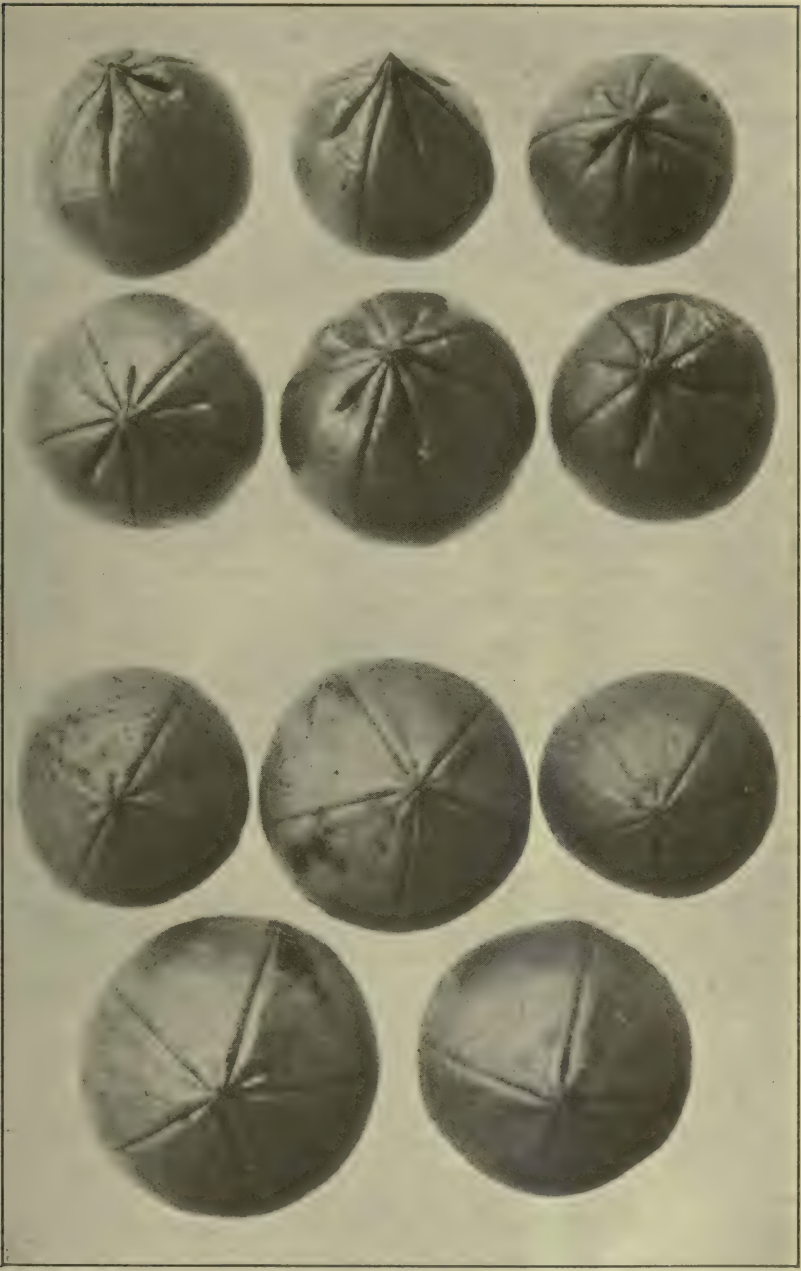

FIGURE 5.—"Split-nose" or "harelip" deformity, showing the grooves or folds between the locks. These are recognized as an inherited tendency, comparable to the harelip defect in animals. They should always be avoided in selection and breeding. (Nearly natural size)

fuzz varies greatly among different varieties, and slight variations of color are usually to be found in the most uniform seed stocks. Conditions of growth also may affect the fuzz characters, so that small variations in the color or density of the fuzz are not to be taken as proving that a seed stock is not pure. On the other hand, there seems to be a general relation between density of fuzz and abundance of lint. Types with little or no fuzz are usually found to have smaller percentages of lint, and extreme variations have been found with neither fuzz nor lint.

The length of the fuzz is also quite variable, and the amount of fuzz taken off in ginning is a factor in the turnout or percentage of lint obtained at the gin. Varieties with long fuzz can be made to give a higher gin turnout than those with short fuzz, but the extra lint percentage obtained by close ginning consists almost entirely of linters. The term "linters" is usually applied to the fuzz and other short fibers which normally are removed by reginning at the oil mill to make it easier to extract the oil. Running more linters into the bales by close ginning adds to the waste that must be separated from the fiber in the spinning mill. The higher turnout at the gin may give the farmer no real advantage, as the commercial grade of the cotton may be reduced. Where premium cotton is being grown, the addition of 2 per cent more linters to the cotton to give a high turnout may lose the farmer a premium of several cents a pound, as buyers often refuse to pay full premiums on wasty cotton.

COTTON COMBING

To determine the length and uniformity of lint in a bale of ginned cotton by the commercial practice of cotton classing is a difficult matter, and the operations, when properly done, require skill obtained only through long practice and experience. The exact length and uniformity of fiber lengths in a sample now may be determined readily and easily by laboratory technologists through recent developments, but such methods, equipment, and conditions are not available to the usual cotton farmer. He may, however, determine these elements of quality by a simple and more practical process, namely, the combing of the lint while attached to the seed. This method consists in parting the lint along the raphe, or seam, marked by a black ridge along the back of the seed, and combing the fibers out straight on each side, as illustrated in Figure 6. When the fibers on one side of the seed have been straightened they are pulled from the seed and placed on a dark background for measuring. Since the lint on each side of a normal seed is alike, only one side need be combed for measuring, unless very careful comparisons are to be made or material is being prepared for exhibits. A thin pocket comb with smooth teeth is suitable for this work, and a small piece of black woolen or velvet cloth glued on a smooth board makes a very good background on which to measure or make comparisons. To determine the length and uniformity of lint in a variety, strain, or progeny, several combings should be made. A good plan is to comb the lint of one seed from each of 25 or more consecutive plants.

Figure 6 illustrates the methods usually employed in combing the lint on the seed to determine the length and uniformity of fiber

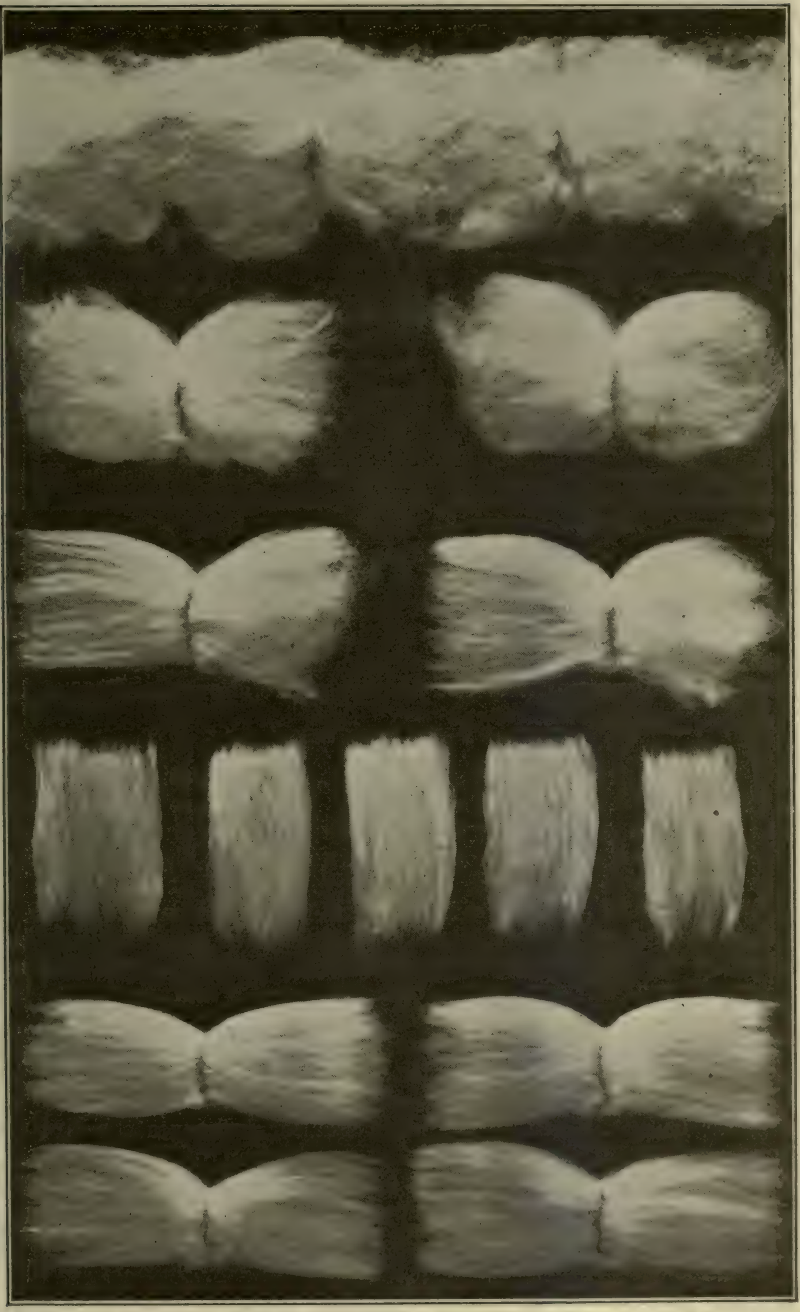

FIGURE 6.—Cottonseed with the staple combed out. (Nearly natural size)

when special care is not being taken. At the top is shown a lock of cotton stretched almost to the point of separating the lint of the individual seeds and with the lint parting along a dark line at the back of each seed. This is the first step in combing. Then one of the seeds that shows the dividing line distinctly should be removed with the lint attached and the division of the fibers completed, as shown in the row second from the top. To comb, grasp the seed and the base of the fibers firmly between the second joint of the index finger and the ball of the thumb, so that the lint of one side of the seed protrudes in front of the partly closed hand. Then insert the teeth of the comb into the portion of the lint that is in front of the finger and comb gently away from the seed to straighten the fibers. If the fibers are tangled it will be necessary to comb more carefully and to change the grip from the seed to the fibers that are partly combed in order to hold them on the seed while the tangles are being removed. If the fibers are badly tangled and broken or become detached from the seed, the combing is spoiled and another must be made. The combing operation is continued until the fibers are straightened, as shown in the third row from the top.

If only the length and uniformity of the lint are to be judged, the combed fiber may be pulled from the seed and placed on a board for measuring, as shown in the fourth row. Care should be taken to grasp the lint firmly when pulling it from the seed to keep it even for measuring. If the combing is to be used in an exhibit or for making accurate comparisons the lint is combed on both sides of the seed. When fibers on both sides of the seed have been straightened, the combing should appear as shown in the bottom rows. Examples of more careful preparations of combings are shown in Figure 7.

LINT PERCENTAGE

The percentage of lint, or gin turnout, is the relation between the weight of fiber and the weight of seed. Farmers are often mistaken in attaching too great importance to the percentage of lint without considering other features. The same amount of fiber ginned from a given number of large seeds will represent a much smaller lint percentage than if ginned from the same number of small seeds. In selection for larger seeds the weight is increased more rapidly than the surface or lint-bearing area, so that the percentage of lint may be reduced even though more lint per acre is obtained. A high turnout is not a proof of high yield.

The number of seeds per boll may be an important factor in the breeding of high-yielding varieties. With the same quantity of seed material divided into a larger number of seeds, the lint-bearing surface is increased. Making the seeds smaller increases the lint percentage and would also increase the production of lint per boll if more seeds were formed. Merely by reducing the size of the seeds, the lint percentage would be increased, though the actual amount of lint would be less; but by reducing the size and increasing the number of seeds, so that the same quantity of seed material is maintained, the lint production would be higher.

An objection to small seeds is that the seedlings may be smaller and weaker so that they may fail to emerge from crusted soil or may suffer more from unfavorable conditions than the larger and

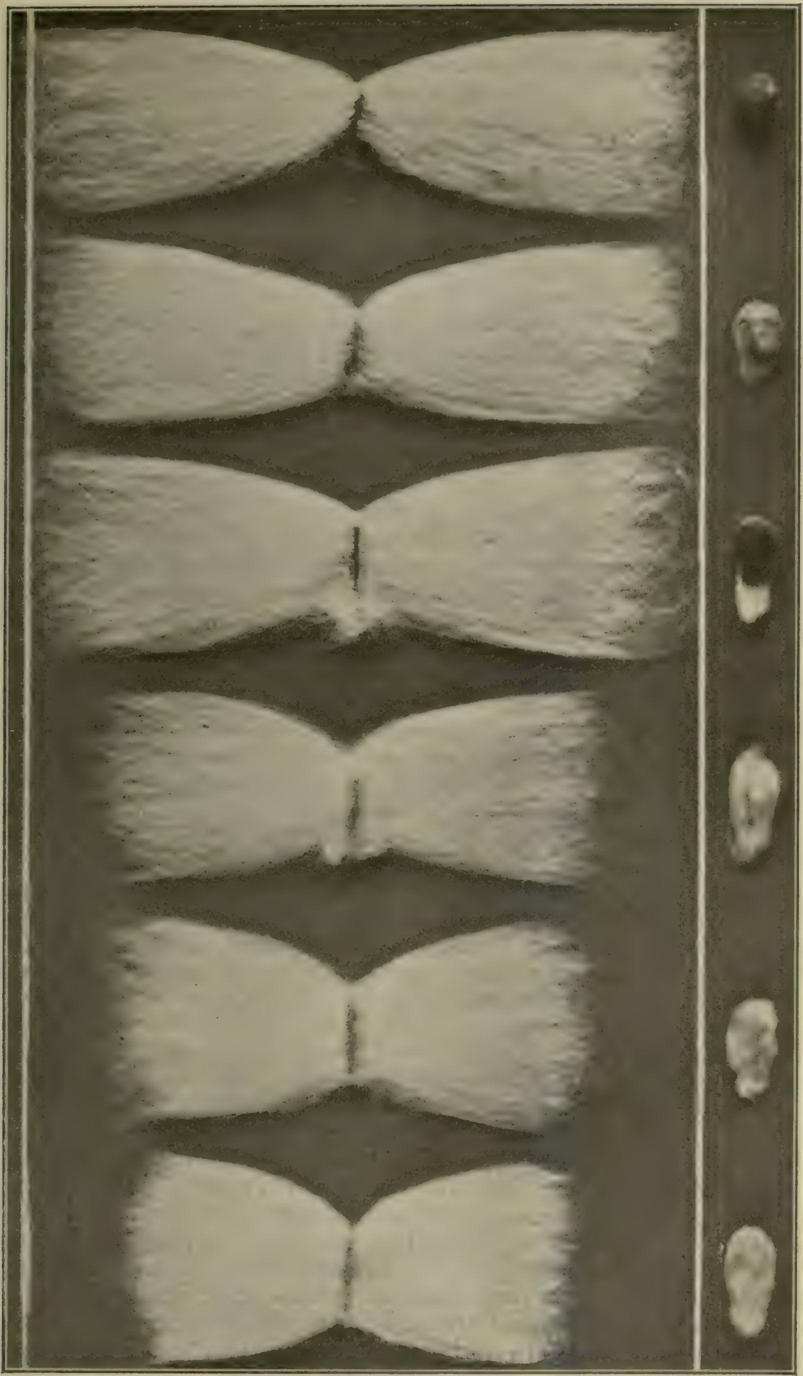

FIGURE 7.—Combed lint and seeds of six superior varieties of cotton. In order from top to bottom these varieties are Seabrook (sea island) Pima (Egyptian), Meade, Durango, Acala, and Lone Star. All these varieties except sea island have been developed by the United States Department of Agriculture and are extensively grown in different parts of the American Cotton Belt. (Natural size)

more vigorous seedlings that come from large seeds. This objection would be slight under favorable conditions, but in many localities uniform stands are difficult to obtain, even with varieties that have large seeds. Thus a limiting factor is the breeding of small-seeded varieties.

SUMMARY OF BREEDING PROBLEMS

Success in the breeding of varieties or strains of cotton and in keeping up their uniformity and other high qualities is largely dependent upon the breeder's ability to hold to one type in selection and to recognize this type under different local conditions. Many of the popular varieties of upland cotton are derivations from the same stocks and possess the same general characters. In fact, some of the varieties are so closely related and so similar in general appearance that they are very difficult to distinguish, and even their "originators" may be unable to point out any definite characters to separate them from their parental stocks. If the breeding problems were well understood, farmers generally would prefer to buy good stocks of seed of tried and well-known varieties, instead of novelties. Many of the highly advertised new varieties have no practical advantages over others already in use, and the putting out of many new kinds may be considered detrimental to the industry, representing an enormous expenditure to little purpose.

One of the principal difficulties encountered in cotton breeding is that the cotton plant responds readily to different conditions of growth and may show many changes of characters that have little or no bearing on the purity of the seed stock. Among the important characters that are greatly affected by environmental and cultural conditions are the size and shape of the plant; the manner of branching; the size, shape, texture, and lobing of the leaves; the size of the bolls; and the number of locks in the bolls. Many slight variations of these characters may be recognized in any field of cotton, progeny block, progeny row, or even on the individual plants of the most uniform stocks. Thus it is necessary to become familiar with the entire range of characters that may be shown by a particular type of cotton, in order to judge the quality of different stocks of seed and to facilitate roguing.

The work of developing new varieties is distinct from that of maintaining uniformity in existing varieties, and the two undertakings are far more different than is generally recognized. To maintain uniformity is the more difficult task, because it is necessary to adhere strictly to one particular type. In order to do this it is necessary to be thoroughly familiar with the various characters of the cotton plant and to know the range of effects of different seasonal and local conditions. A superior type of cotton may be found by one who has only a limited knowledge of the characters that go to make up a superior plant, but one must be able to recognize many characters and take into consideration the endless slight differences that may occur in order to maintain a high standard of uniformity in a select stock.

More definite knowledge of the cotton plant should enable breeders to find new characters or to establish and maintain new combinations of characters that would serve as improvements over the present varieties. Such changes may best be accomplished through the use and gradual improvement of a few superior varieties and by organized breeding efforts of entire communities or districts, instead of depending upon the desultory efforts of scattered individual seed growers. The same varieties are being grown successfully over wide areas of the Cotton Belt, and only one variety is needed in each locality.

A reduction in the number of varieties not only would lessen the work of maintaining and further improving the seed stocks but would add greatly to the value of the product and to the returns received by the growers. Such advantages have been shown by growing the Acala variety in California, where provisions have been made to exclude all other varieties. This exclusion of other varieties prevents hybridization and the subsequent deterioration of the stocks of pure seed. Such protection against mongrel breeds must be recognized as an essential requirement in cotton production, to establish and maintain a creditable cotton-growing industry.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1662

Husker-Shredders

in Corn-Borer Control

IN SECTIONS infested with the European corn borer it has been found that, with proper adjustment and careful operation, husker-shredders kill from 95 to 98 per cent of the borers in the stalks. Most of the borers are killed while passing through the snapping rolls.

The operator should train his ear to the sound made when the husker is running normally. Loose connections may thus be quickly detected.

Serious damage may be caused by a loose knife or shredder bar striking on the shear bar. The head bolts should be gone over periodically, especially after the knives or shredder bars in the head have been changed.

Proper lubrication is very important. The bearings of the head, snapping rolls, husking rolls, and the blower require frequent attention.

Shredder heads, combination heads, and knife heads cutting 2 inches or less are about equally effective in destroying corn borers.

The greatest number of borers is killed when fodder is cut into half-inch lengths and the least number when the fodder is cut into 4-inch lengths. Live borers in the stored fodder in excess of 2 per cent may become a source of increased infestation.

This bulletin is based on tests run on husker-shredders during 1928–29 in the vicinity of Toledo, Ohio, by the Division of Agricultural Engineering of the Bureau of Public Roads. It describes the operation of the husker-shredder and makes suggestions as to its operation and care with special reference to corn-borer control.

Washington, D. C. Issued March, 1931

HUSKER-SHREDDERS IN CORN-BORER CONTROL

By I. F. Reed, *Assistant Agricultural Engineer*, and W. R. Humphries, *Senior Engineering Aid, Division of Agricultural Engineering, Bureau of Public Roads*

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INTRODUCTION

THE HUSKER-SHREDDER has been in use in sections of the Corn Belt for the past 35 years. Its use, however, was more widespread before the introduction of the silo and the tractor, and before legumes became so universally grown. These changes resulted, on many farms, in a substitution of the new feed crops for the shredded stover, and in a decrease in the roughage requirement due to the replacement of horses by tractors. Shredding is still important, however, in those districts and on those farms where there is a shortage of hay or straw for roughage; where the number of cattle is too small to justify a silo; where large herds of dairy cows are kept, requiring large quantities of roughage for feed and for bedding; and where shredding is done principally to get the corn husked. In western Ohio and in southeastern Michigan 25 per cent of the 1927 corn acreage was shredded, while smaller acreages were shredded in Indiana and the States to the westward.

Farmers who shred regularly express a preference for shredded stover over the whole stalks for feeding and bedding. The stover is under cover and conveniently stored for feeding, is easily handled, and makes excellent bedding and manure. Stables and barnyards can be cleaned much more easily than when whole stalks are fed, for it is a difficult task to pull out whole stalks that have been tramped all winter. In territory infested by the European corn borer the long stalks must be destroyed, but when shredded stover is fed, the débris from the barnyard can be spread directly on the field, because it has been determined by detailed tests that the husker-shredder kills a high percentage of the borers contained in the infested stalks. For this reason the husker-shredder has become an important agency in borer destruction.

Success in the use of the husker-shredder, both as a husking machine and for corn-borer control, depends largely upon the care it receives and its handling during operation. Proper handling and care insure greater efficiency of operation, longer life of the machine, fewer delays, and smaller repair bills.

HOW THE HUSKER-SHREDDER OPERATES

When cornstalks are fed into a husker-shredder they are seized by and drawn between the snapping rolls which are held together by spring pressure. As the stalks pass between the rolls the ears are snapped off the stalks and dropped on the husking bed below. The husking rolls then remove the husks and drop the ears into a conveyor which delivers them to the wagon or crib.

The stalks pass from the snapping rolls over a shear bar where the shredding or cutting is done by the revolving head. The shredded stover falls on a shaker where any shelled corn and dirt are removed, after which it is dropped into the blower fan and is blown into the mow or stack. The shelled corn passes over a cleaning screen and then falls through a blast of air into the shelled corn elevator which delivers this corn to the bag or box ready for feeding.

There are, of course, variations in the accomplishment of these operations by the different makes of huskers. This bulletin deals with the principal mechanical features involved in most of the standard husker-shredders now on the market.

HUSKER-SHREDDER UNITS

FEEDER

Three types of feeders are used on husker-shredders, namely, the hand, gravity, and slatted-conveyor feeds. The hand feed was the first type used and is found on many of the 4-roll huskers at the present time. In using this feeder, the operator after cutting the bands of the bundles pushes the stalks forward until they are gripped by the snapping rolls. To do this the operator must work close to the rolls, and for his protection a safety clutch lever, operated by the left leg, is usually provided. This lever should be tried often to be sure of its effectiveness.

The gravity feeder is used on machines having combination snapping and husking rolls. (Fig. 1.) The operator spreads the bundle and lets the stalks slide down into the snapping rolls. With this type of feed there is little danger of injury from the snapping rolls, consequently no safety device is provided.

The conveyor type of feeder is used on all huskers larger than 4-roll that use horizontal snapping rolls. The operator stands facing the snapping rolls with the feed table between himself and the rolls. (Figs. 2, 3 and 4). He spreads the bundle on the conveyor which carries it forward to the rolls. Machines using this type of feeder are equipped with a safety device so that the feeder and snapping rolls may be stopped whenever the operator is in danger or when the husker tends to clog.

SAFETY DEVICES

All safety devices on huskers equipped with the conveyor-type feeder are designed to enable the operator to stop the feeder and the snapping rolls at will. Certain other types of safety devices cause all the moving parts of the machine to stop except the head and the blower fan. Two methods of operating the safety clutches are used. Either a lever is provided within easy reach of the operator (fig. 3), or his weight is required on the feeding platform to keep the clutch engaged. The safety lever often is placed across the front of the feed table so that when the operator leans too far forward the conveyor will be thrown out of gear. Either of these methods is

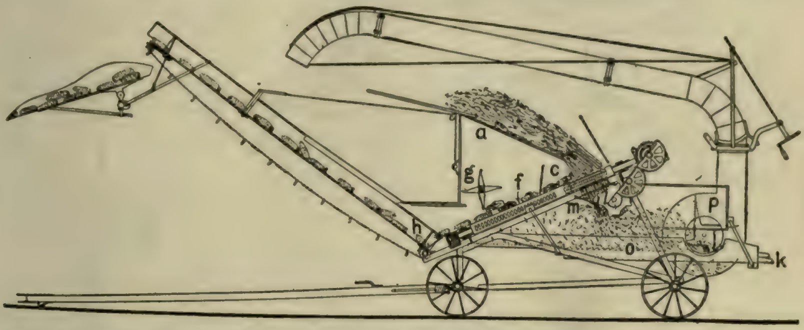

FIGURE 1.—Husker-shredder equipped with gravity-type feeder (*a*); *c, f*, combination snapping and husking rolls; *g*, ear-corn kicker and carrier (*h*); *l*, cutter head; *m*, shear bar; *o*, combination shaker and cleaning shoe using no-choke sieve; *k*, shelled-corn pan; *p*, blower

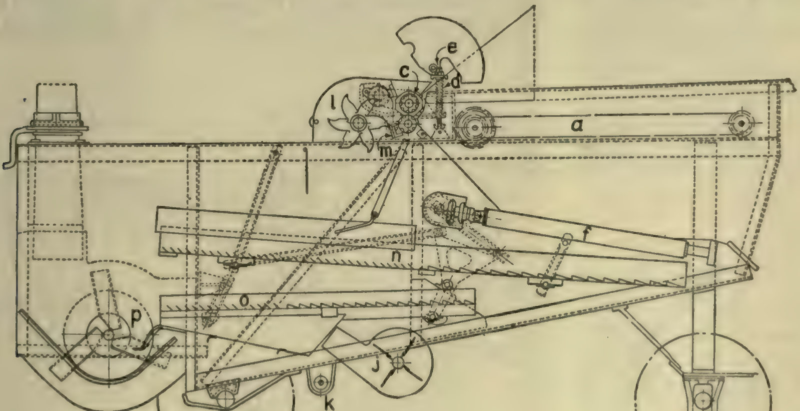

FIGURE 2.—Husker-shredder equipped with conveyor-type feeder (*a*); *c*, horizontal snapping rolls; *d*, snapping-roll springs and adjusting nuts (*e*); *f*, husking rolls; *n*, shaker-type conveyor; *o*, cleaning shoe and fan (*j*); *k*, cross auger; *l*, shredder head; *m*, shear bar; *p*, blower

effective. With the conveyor type of feeder there is little danger of injury to the operator, and the safety clutch is used primarily for stopping and starting, or for stopping when the husker clogs. If the snapping rolls clog the stalks should be dislodged with a softwood stick. One should never reach in with the hands as the clutch may accidentally engage. A hand or an arm is a high price to pay for carelessness.

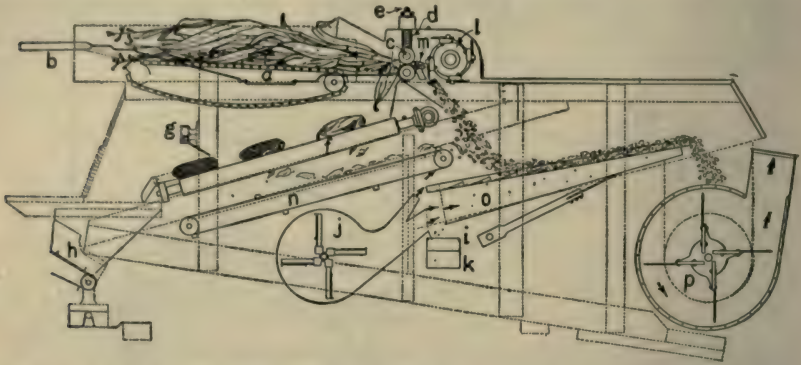

FIGURE 3.—Husker-shredder equipped with conveyor-type feeder (*a*); *b*, safety lever; *c*, horizontal snapping rolls; *d*, snapping-roll springs and adjusting nuts (*e*); *f*, husking rolls; *g*, ear-corn kicker and carrier (*h*); *o*, cleaning shoe and fan (*j*); *i*, *k*, cross shake and screen; *l*, cutter head; *m*, shear bar; *n*, slatted conveyor; *p*, blower

SNAPPING ROLLS

The snapping rolls which operate in pairs pinch the ears off the stalks as the latter are pulled through. The axis of one of the rolls is fixed while that of the other floats under the pressure exerted by the snapping-roll springs. Pressure on the snapping rolls can be varied by the adjusting nuts shown at point *e* in Figures 2 to 5 inclusive. For ease in feeding a low pressure is used on the rolls, especially when the butts of the stalks are wet or frozen. Such an adjust-

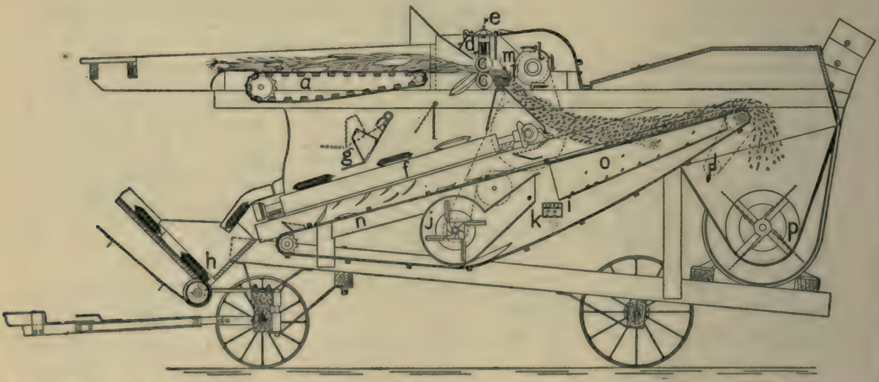

FIGURE 4.—Husker-shredder equipped with conveyor-type feeder (*a*); *c*, horizontal snapping rolls; *d*, snapping-roll springs and adjusting nuts (*e*); *f*, husking rolls; *g*, ear-corn kicker and carrier (*h*); *o*, cleaning shoe and fan (*j*); *i*, *k*, cross shake and screen; *l*, cutter head; *m*, shear bar; *n*, slatted conveyor; *p*, blower

ment is objectionable because an excessive amount of corn is shelled from the ears, and the husker has a tendency to clog.

The number of snapping rolls varies. Some machines have two rolls only (fig. 4), while other machines have two pairs of rolls mounted parallel with the head, one pair above the other. Most huskers having the parallel mounting use only one pair of rolls. These are of the same length as the shredding cylinder. Another common type of mounting consists of two pairs of rolls mounted with their axes at right angles to that of the shredding cylinder and set at an angle of approximately 45° with the horizontal. (Fig. 5.) The third type is the combination rolls, the upper ends of which are used for snapping and the lower ends for husking. (Fig. 1.) This type has gravity feed.

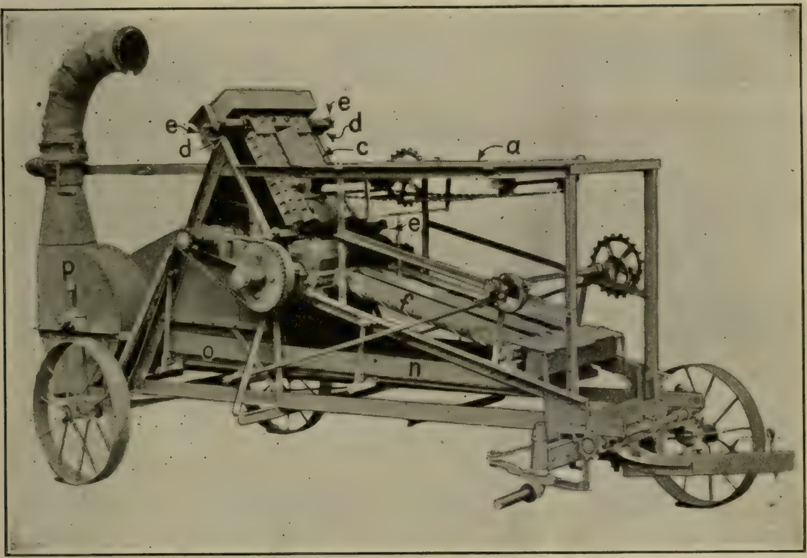

FIGURE 5.—Husker-shredder equipped with conveyor-type feeder (*a*); *c*, vertical snapping rolls; *d*, snapping roll-springs and adjusting nuts (*e*); *f*, husking rolls; *n*, combination shaker-conveyor; *o*, cleaning shoe; *p*, blower

The surface of snapping rolls varies considerably with different makes of huskers. Some have two corrugated rolls working together, some have a corrugated roll and a pitted roll, while others have two pitted rolls. These rolls are timed according to the work being done. The corrugated rolls, for example, may be so timed that the two bars meet, followed by two grooves, or the bar of one roll may meet the groove in the other. The first is the better adjustment for large or frozen stalks, but it has a tendency to shell more corn. For ordinary operation the second adjustment is preferable.

HUSKING ROLLS

A husker-shredder is rated in size according to the number of its husking rolls, which range from 2 to 12. The 4, 6, and 8 roll machines are most common. The husking capacity and power required depend upon the number and size of the husking rolls.

The husking rolls (figs. 2 to 5) are located below and in front of the snapping rolls and operate in pairs. Pegs are inserted in the rolls, which must be so timed that the pegs on one roll of a pair fit into pits on the other as the rolls revolve. The number and size of the pegs used are determined by the condition of the corn. If the husks are tight and are hard to remove, pegs longer than the regular husking pegs may be used. It is possible to insert extra pegs in the husking rolls of many huskers.

Springs hold the husking rolls together. These springs should be so set that the rolls will be held together just tightly enough to grasp the husks and pull them off the ears as they are loosened by the husking pegs. If the rolls are set too tightly, undue wear on the husking-roll bearings will result.

HEAD

The head (*l*, figs. 1 to 5) placed back of the snapping rolls cuts or tears the stalks as they pass through the latter. In machines having a shear bar the head shaft is parallel with the shear bar; in other machines the shaft is parallel with the snapping rolls.

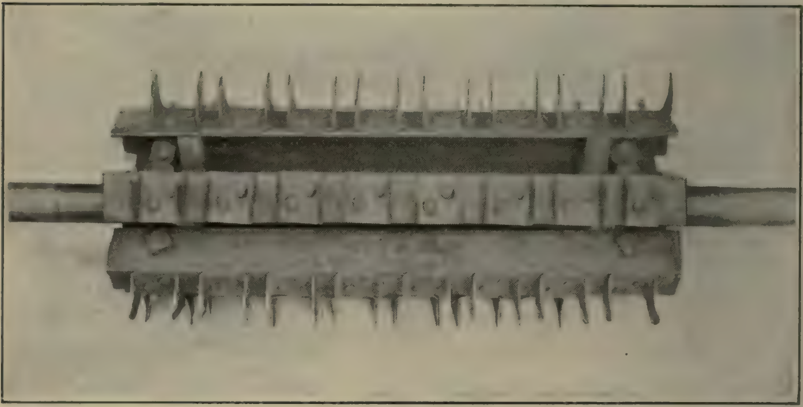

FIGURE 6.—Shredder head showing hooked teeth riveted to angle-iron bars bolted into the head. Six, eight, ten, or twelve bars are used in the shredder head according to the size and make of the husker

Three types of heads are used, the shredder head, the cutter head, and the combination head. The shredder head is fitted with teeth and, as the name indicates, shreds the stalks as they are advanced by the snapping rolls. (Figs. 6, 7, and 8.) The cutter head (figs. 9 and 10) which consists of from one to four knives cuts the stalks into pieces from one-half inch to 4 inches long. The different lengths may be obtained in some machines by changing the number of knives (the greater the number the shorter the cut), and in other machines by changing the gears that drive the feed apron and snapping rolls. The slower the snapping roll speed with respect to the head speed, the shorter the cut. The combination head (figs. 11 to 14) is fitted with both shredder teeth and knives.

The pulley on the head shaft is belted directly to the power unit which operates the husker-shredder, and the speed of the head determines the speed of the other units of the husker. It is important, therefore, to keep the head up to rated speed to insure efficient operation of the machine. The speed of the head is rated by manufacturers in number of revolutions per minute and is indicated on the machine. Shredder heads generally are rated at 1,000, and cutter heads at 750 revolutions per minute, while combination heads vary in speed according to make of machine.

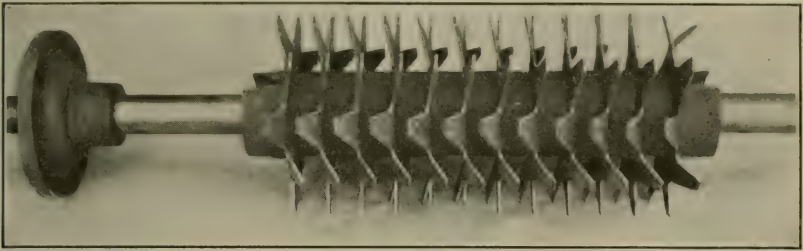

FIGURE 7.—Shredder head with blades stamped out of a steel plate. The teeth are staggered so that every point of the shear bar is covered by a shredder tooth during one revolution of the head

SHEAR BAR

Shear bars, when used on huskers equipped with horizontal rolls, are mounted just back of the lower roll. (Fig. 2 *m*.) On machines using vertical or combination snapping rolls, the shear bar is mounted (fig. 1, *m*) with one edge close to the snapping rolls and the other toward the head. The knives on the cutter head should clear the shear bar about one-sixteenth of an inch. The stalks pass through the snapping rolls, over the shear bar, and are cut or shredded against this bar. To function best, the shear bar should have a sharp working edge. This edge is maintained differently in different machines, as by turning the shear bar over, turning the bar end for end, or replacing it entirely if the bar is not reversible.

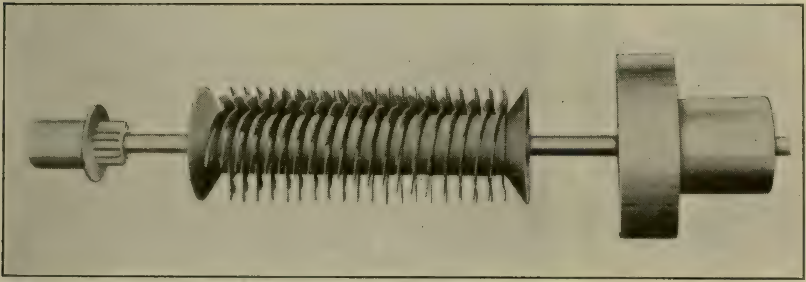

FIGURE 8.—Saw-tooth shredder head. The shredder teeth are stamped steel and are arranged in the form of a spiral. Thus one revolution of the head causes a tooth to pass all points on the shear bar

The shear bar must be used on huskers equipped with cutter heads but may or may not be furnished with shredder heads.

SHELLED-CORN SEPARATING AND CLEANING DEVICES

Some husker-shredders leave a smaller percentage of the live borers in the shredded stover than do others even though the kills may be the same. This is due to differences in the effectiveness of the separating devices. Huskers with characteristics similar to those shown in Figure 2 are effective in separating the borers from the shredded stover. The long shaker with the slat work at the rear end allows the shelled corn, live borers, pieces of cob, and bits of shredded stover to fall through onto the shoe below, where the shelled corn is separated out. Most of the surviving borers remain with the shelled corn because of the fact that when they instinctively curl up their size is about that of a kernel of corn. The shelled corn then passes over a fine screen and into the shelled-corn auger or cross shake. Some of the borers, however, go through this screen and are found on the ground under the machine.

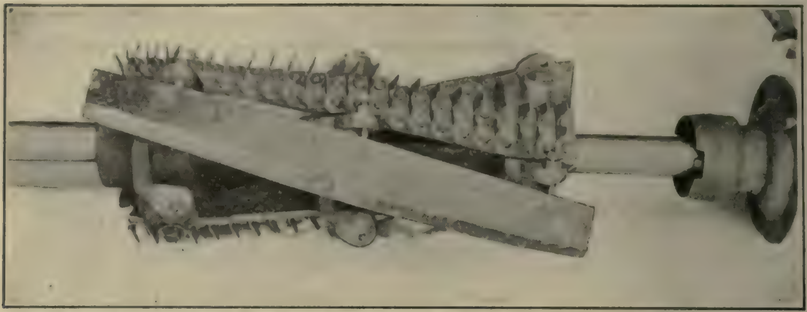
FIGURE 9.—A cutter head equipped with four full blades. This head may be operated using two blades, one on each side of the head, or using one blade with counterbalances on the opposite side of the head

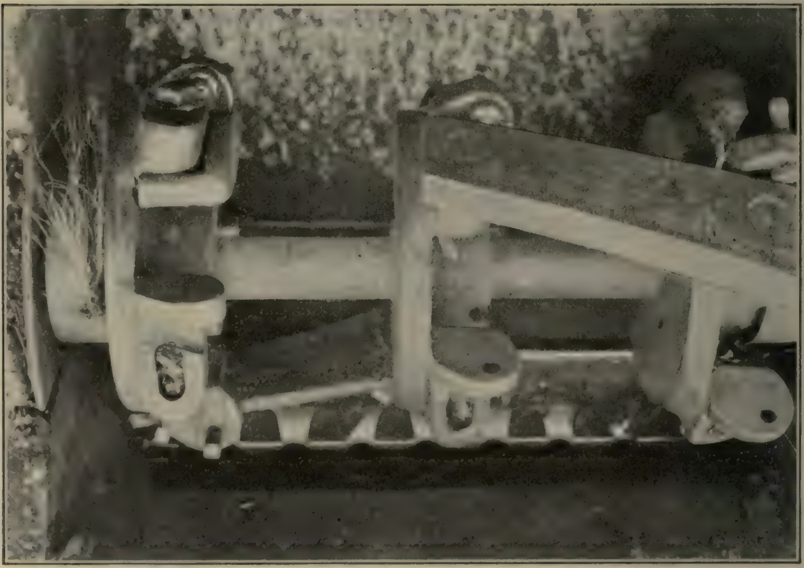
FIGURE 10.—Cutter head in position equipped with two half-knives. The claim is made that two half-knives set up less vibration than one full knife with counterbalances

Figures 1 and 5 show two types of huskers which use a single shaker running the entire length of the machine. The front part of the shaker is made of corrugated steel fitted with riveted-on-fishbacks to carry the husks and pieces of stalk back from under the husking rolls. The shaker has a no-choke sieve extending from a point under the head to the rear end of the machine. This allows the shelled corn, live borers, and other material to drop on the bottom below. The shaking motion causes the corn to move to the rear of the machine, pass over a fine screen, and to come out at the rear end.

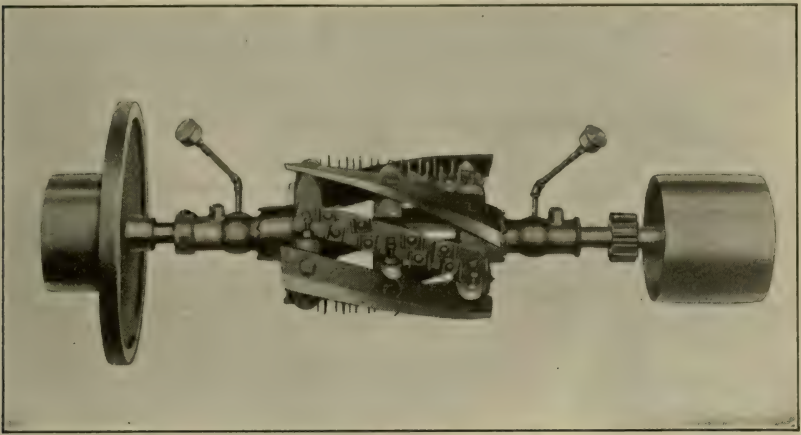

FIGURE 11.—A combination head equipped with four knives and four shredder bars. It is possible to equip this type of head with 2 or 4 knives, 2 or 4 shredder bars, or combination of 2 or 4 knives with 2 or 4 shredder bars

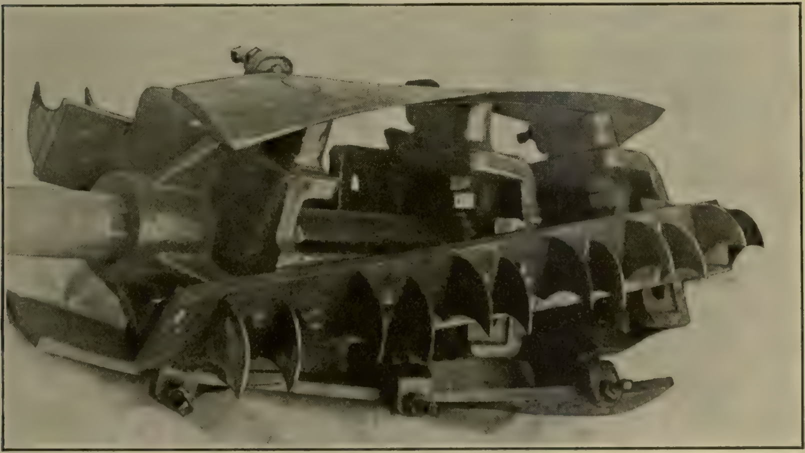

FIGURE 12.—Combination head equipped with two shredder bars and two knives. This head may be converted into a 2-knife head by removing the shredder bars, or into a 4-knife head by replacing the shredder bars with knives

Two other types of separating devices are shown in Figures 3 and 4. Both have the slatted-chain conveyor to move the husks back from under the husking rolls. The machine shown in Figure 3 has a separator made up of a no-choke sieve with a sheet-iron bottom starting below the head and continuing to the rear. The shelled corn and some of the live borers are shaken out and fall on this bottom, then slide down into the cross shake. In the machine shown in Figure 4 the slatted chain continues back over the shaker and returns under the machine. The shaker has a perforated top and vibrates under the conveyor. The cross shake on these huskers has a screen bottom which separates most of the dirt from the shelled corn before delivering the corn to the bag.

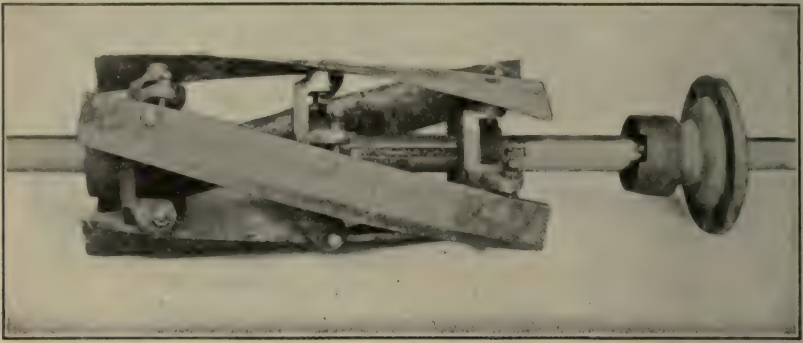

FIGURE 13.—Combination head equipped with two knives and two shredder bars

BLOWER

The blower unit (*p*, figs. 1 to 5) delivers the shredded or cut stover to the mow, shed, or stack. When shredding, the hood on the end of the blower pipe should be moved from time to time to distribute the stover evenly over the pile. This prevents the heavy, moist pieces from piling up in one place and thus causing spoilage of stover. Care should be taken to maintain proper speed of the blower, otherwise clogging may result.

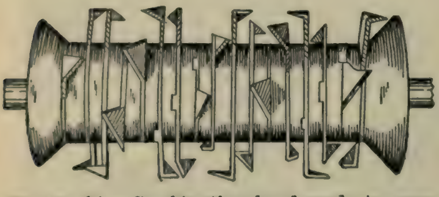

FIGURE 14.—Combination head made to operate in a husker without a shear bar. The triangular-shaped end on these shredder knives is sharpened so that it cuts the stalks. The edge of the blade from the knife section to the spacer rings has a serrated edge that tends to shred the stalks

TRANSPORT TRUCK

Four-roll or larger husker-shredders are equipped with 4-wheel transport trucks. (Figs. 4 and 5.) The rear wheels are mounted on a plain, dead axle. Two types of front axles are used, the pivot or auto type axle and the fifth-wheel or wagon type. There is less tongue whipping with the pivot axle, but this factor is of little consequence when the machine is moved with a tractor.

CARE OF HUSKER-SHREDDER

PREPARATION FOR THE SEASON'S WORK

The preparation of the husker for the coming season's work may start as soon as the work of the previous season is finished. Any new parts needed should be ordered early because of possible delays in shipment. Every nut should be tried and tightened if necessary. The knives should be sharpened if the cutter head is to be used, or the teeth straightened if the shredder head is employed. If the edge of the shear bar is rounded badly a new edge should be applied. While all bearings should be adjusted to remove any lost motion, in doing this care must be used not to cause binding and consequent heating. Each shaft should turn easily by hand. Broken slats in machines having slatted shakers should be replaced, and bent lips on the shaker having the no-choke sieve should be straightened. Any broken boards in wood-frame huskers should be replaced and any dents in the steel housings taken out. Belts should be examined and repaired, and replaced where necessary. A belt lacing in the condition shown in Figure 15 is dangerous to the operator and likely to result in delays at a busy time. Broken or badly worn chain links should be replaced.

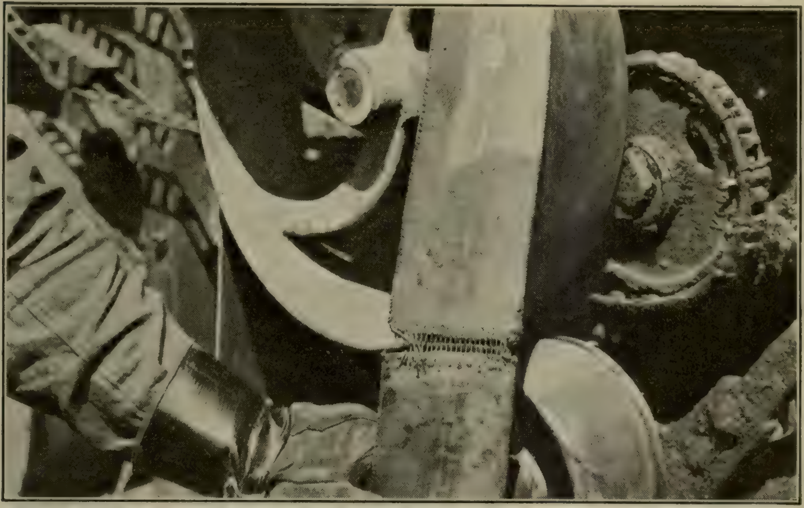

FIGURE 15.—Belt lacings in this condition should be repaired to prevent the end of belt tearing out

Any repairs made during the off season will save time and trouble when husking time arrives. The operator should make a practice of having his husker in the best possible condition at the beginning of each season. His husker will then last longer, and if custom work is done his customers will be better satisfied if he is able to operate continuously whenever the weather is favorable.

CARE DURING OPERATION

The operator of any power-driven machine should become accustomed to its normal sound. This is especially important in the case of a machine that performs a number of operations, such as the husker-shredder. Any unusual noise should be investigated immediately. A knife or shredder bar may work loose. This should be located and the bar tightened immediately. (Fig. 16.) Prompt tightening of a loose knife may prevent damage to the head and its supporting casting. The repairs needed in case of an accident of this type are expensive.

Serious damage may further result from undetected stones or other hard material fed with the stalks into the husker. In such a case an emergency stop should be made immediately and the foreign material removed. Even though the snapping rolls or the head may have escaped damage the blower unit would be subject to damage.

All bolts on the husker should be checked periodically. Many of them can be checked on days when it is not possible to husk, but especial attention should be given to the head bolts and those holding the shear bar, and main bearing caps. Particularly should the head bolts be checked often after knives or shredder bars have been changed. The operator may check the tightness of the bolts in the head of his machine a dozen or more times without finding a loose bolt, but if he should find one at the next inspection he will have been repaid for all his effort.

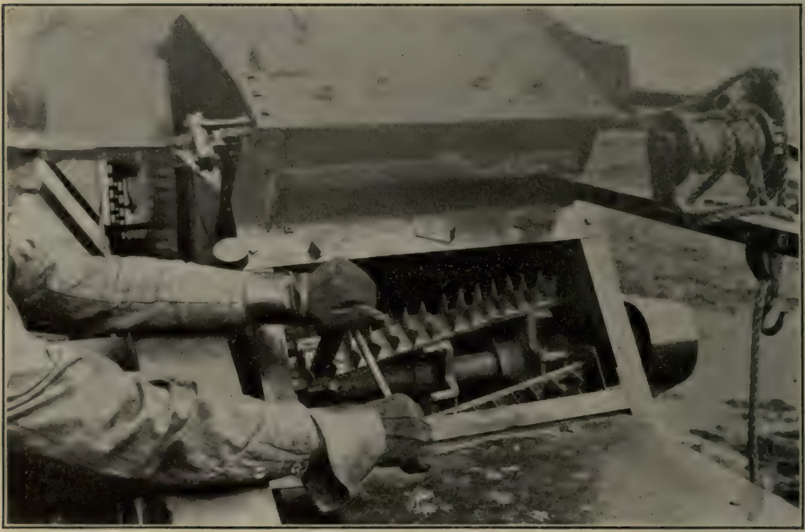

FIGURE 16.—Head bolts should be checked periodically, especially after knives or shredder bars have been changed

The knives on the cutter head should be kept sharp. This will save power and will reduce the strain on the husker. The clearance between the knives and shear bar should be adjusted carefully and kept at about one-sixteenth of an inch, although for corn-borer control a slightly greater clearance is more effective. Care should be taken to have the clearance sufficient to prevent any possibility of a knife catching on the shear bar.

Before engaging the tractor clutch, particularly in cold weather, the husker should be turned by hand to see that all parts are free. If some of the parts are frozen together a little hot water will loosen them. Snow and ice often lodge around the snapping rolls and cause the lower roll to freeze to the shear bar. Another common trouble is the freezing down of the conveyor feeder. If there is snow or ice in the butts of the stalks, when stopping work the clean-out doors at the lower end of the shelled-corn elevator and other elevators should be opened and all snow and slush removed.

The husker is generally set up just outside the barn, where it remains until the job is finished. Here it receives some protection from high winds, while the end of the blower, being inside the barn, is protected against snow and rain. If, however, the blower pipe is exposed to the weather it should be lowered at night, placed on the transport bracket, and the end covered. The feeder and feeding gears should likewise be covered each night so as to prevent the freezing down of the conveyor chain and the snapping rolls in the event of bad weather. Belts should be covered, or removed and put in a dry place.

PREPARATION FOR STORAGE

At the end of the husking season the machine should be carefully prepared for storage. First clean the machine thoroughly both inside and out, and then grease all bright metal parts to prevent rusting. The head parts, snapping and husking rolls, blower fans and metal fodder chute leading to the blower, should be given especial attention. Any wooden parts showing signs of weathering should be painted with a good grade of paint. The entire machine should be painted at intervals depending upon the weathering it receives. The old grease and oil should be washed out of the bearings to dispose of any dirt or grit that may have accumulated, and replaced with fresh materials. A list should be made of all parts that need replacing for the next season's runs, and any minor repairs or adjustments needed should be noted.

Often the husker-shredder may be stored to better advantage by removing some of its parts. A space otherwise too small may be used if this is done. The shed that houses the husker should have good side walls and a roof free from leaks. If the floor is of dirt or cinders, it should be fairly level and well drained, and boards should be placed under the truck wheels.

BELTS AND CHAINS

Belts supplied on husker-shredders usually are of waterproof rubber composition and require very little attention. They should, however, be run with the smooth side next to the pulley, otherwise the rib will be worn away and the life of this belt shortened. Sometimes leather or canvas belts are used. Leather belts should be run with the hair (smooth) side next to the pulleys, while either side of a canvas belt may be next to the pulleys. To obtain maximum service from canvas and leather belts they should be protected from moisture and treated to keep them soft and pliable. Neatsfoot oil should be used on leather belts and a good belt dressing on canvas belts. Never use a mineral oil on belts.

Belts should be run just tight enough to prevent slipping and flapping, but not so tight as to set up excessive strains in the shafts and cause heating of the bearings. Wiping the inside of a new rubber belt with a damp cloth to remove the powder will reduce its slippage. When belting up a machine, damage to the belt may be prevented by turning the belt on to the pulley rather than resorting to hammering or prying.

Detachable link chains should be run as shown in Figure 17. Otherwise there is a tendency for the pull of the load to close the hook on the links and cause them to bind. Roller chains, which are used on the heavier drives of some huskers, require a good grade of machine or engine oil. While roller chains are usually shielded from dirt they should nevertheless be cleaned periodically. To clean them, they should be removed, rinsed in gasoline or kerosene, dried, and dipped in an oil bath. Detachable-link chains may be lubricated with engine oil or cup grease. Chains should be kept tight enough to permit of only slight sag.

LUBRICATION

An important consideration in the care of any machine is its lubrication, the purpose of which is to reduce friction between moving surfaces and thus prevent unnecessary wear. An oil film must be maintained between these surfaces; this is accomplished by one of the following methods commonly used on machines of the husker-shredder type: (1) Wick oilers; (2) grease cups; (3) pressure lubrication.

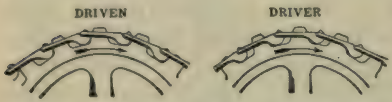

FIGURE 17.—The hooks on chain links must be on the outside and run forward

Where wick oilers are used engine oil or a good grade of machine oil should be used. The wicking in the cups or wells should be kept loosened so that a sufficient flow of oil to the bearings will be maintained. A soft cup grease is used when either the grease cup or the pressure system is provided. A grease cup is filled and screwed down until the grease starts out of the end of the bearing. This not only insures complete lubrication, but also forces out any dirt or grit that may have collected. If the pressure system is used, grease coming out of the end or other parts of the bearing is reasonably good evidence that the part is thoroughly greased.

The head shaft, blower shaft, and snapping-roll shafts operate at high speed and under high bearing pressure; hence to insure thorough lubrication they should be greased at least three times during each half-day's run. The husking-roll bearings, the bearings on the shelled-corn cleaning fan, and the gearing that drives the snapping rolls and feeder should be oiled at least once during a half-day's run. The pitman bearings can not be oiled while the husker is in operation but should be thoroughly oiled before starting each half-day's run. The transport trucks should be greater every 50 or 60 miles. Always use engine oil or a good grade of machine oil. Avoid the use of used crankcase oil, since it has little body and contains much grit and dirt. Never use axle grease in grease cups. Keep all oil and grease supplies free from dirt.

The husker-shredder is used in the fall and winter when an oil becomes thick and does not flow readily. The oil may be warmed by the heat of the tractor and thus caused to flow from the can, but it may thicken on contact with the cold bearing caps and other parts, and cause inadequate lubrication. Under these conditions use an oil that is thin enough to flow quite freely when cold. In extremely cold weather it may be necessary to mix kerosene with the oil to give it the required fluidity.

OPERATION AND ADJUSTMENT FOR CORN-BORER CONTROL

In areas infested with the European corn borer the husker-shredder has proved to be very effective in destroying borers. Tests have shown that with proper adjustment and careful operation, kills of from 95 to 98 per cent of the borers can be made. Most of the borers are killed while passing between the snapping rolls, but the mortality is increased by the action of the head, and probably still further by contact with the blades of the blower fan. The effectiveness of the shredder head, the combination head, and the knife head cutting lengths of 2 inches or less, is about the same.

EFFECT OF SNAPPING-ROLL PRESSURE ON THE PERCENTAGE OF BORERS KILLED

Snapping rolls alone, properly adjusted, kill from 80 to 90 per cent of borers in the stalks, the highest kills being obtained when the pressure on the rolls is greatest. There is a direct relationship in all types of huskers between pressures on the snapping rolls up to 1,000 pounds, and the percentage of borers killed. Tests have shown that the kill is raised approximately 6 per cent by increasing the pressure on the snapping rolls from 400 pounds to 1,000 pounds, but that the mortality is only slightly further increased with pressures in excess of 1,000 pounds.

LIVE BORERS IN SHREDDED STOVER

Some of the borers surviving the snapping rolls and the cutter or shredder head are shaken out of the stover and deposited in the shelled corn, or on the ground under the machine, where they can be easily destroyed by methods described later. The living borers remaining in the stover are blown into the mow. Repeated tests have shown that practically all such borers are destroyed ultimately by (1) injuries received while passing through the husker, (2) drying out of the fodder, (3) being fed to livestock, or (4) being trampled into the manure, incident to the feeding of the shredded stover or its use as bedding.

It has been found by experiment that the higher percentages of live borers are left in the stover when the lower snapping-roll pressures are used. Thus it can be assumed that any adjustment of the snapping rolls and head that will give the highest kill will also tend to leave the smallest percentage of the borers alive in the shredded stover. As shown in Table 1, knife heads that cut the stover in 4-inch lengths leave the highest percentage of the borers alive in the cut stover, and those making ½-inch cuts leave the lowest percentage.

TABLE 1.—*Relation between the lengths of cut, per cent of borers killed, and per cent of borers left alive in the cut stover*

Length of cut	Borers killed	Borers left alive in cut stover
Inches	*Per cent*	*Per cent*
4	93.2	4.5
2	95.0	2.1
1	96.4	.6
½	98.0	.5

LIVE BORERS IN SHELLED CORN AND UNDER HUSKER

The borers left alive in the shelled corn by the husker can best be killed by feeding the corn to chickens or hogs. This shelled corn never should be mixed with the ear corn as the live borers would then be able to bore into the pith of the cobs where, being protected, they might complete their life cycle. The shelled corn should be fed in a trough or on a tight feed floor where the borers will be picked up before they can obtain shelter by crawling into straw, corncobs, or other material. If the corn is not to be fed, it should be treated in such a way as to kill the borers. This may be done by grinding, or by heating it to 160° F. and keeping it at this temperature for at least five minutes.

After the completion of the work at each set-up the material on the ground under the husker-shredder should be carefully collected and burned to kill the borers that may have been missed.

EFFECT OF SPEED OF HEAD ON PERCENTAGE OF BORERS KILLED

The percentage of borers killed varies directly with the speed at which the machine is operated up to normal speed, when the kill is at a maximum. Usually this is 1,000 revolutions per minute for the shredder head, and 750 to 850 revolutions per minute for knife or cutter heads. Running the head at 20 per cent below rated speed was found to decrease the kill of borers from 2 to 3.5 per cent, and to increase the percentage of borers left alive in the shredded stover when either a shredder head or a combination head was used.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1663

WINTER LEGUMES for GREEN MANURE in the Cotton Belt

THE USE OF WINTER LEGUMES for green manure in the Cotton Belt has greatly increased in recent years. Austrian winter peas, hairy vetch, and smooth vetch are the crops most used, while crimson clover, bur clover, and sour clover are used in limited areas.

A legume green-manure crop reduces erosion and also the leaching of plant food. It improves the physical condition of the soil by the addition of organic matter and through the nitrogen-gathering bacteria adds plant food. It also increases yields of subsequent crops grown with it in rotation.

Winter legumes should be inoculated at the time of seeding. Commercial fertilizer consisting largely of superphosphate should be used, especially when growing a legume crop on land for the first time. Barnyard manure also increases the growth of winter legumes and greatly aids in getting the plants inoculated.

Seedings should be made the latter part of September or early in October. Earlier seeding may result in injury by nematodes, and later plantings often result in poor stands and growth.

The green-manure crop should be turned under two weeks preceding planting corn and three weeks before planting cotton.

Washington, D. C. **Issued April, 1931**

WINTER LEGUMES FOR GREEN MANURE IN THE COTTON BELT

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INTRODUCTION

THE USE of winter legumes for green manure in the Cotton Belt has greatly increased in recent years, largely on account of demonstrations by the State and Federal experiment stations and the practical experience of farmers. The value of this practice and the best crops for the purpose have been indicated by these experiments.

By legume is meant a plant that bears pods like the pea or the bean. These pods are 1-celled and usually split in two pieces.

By winter legume is meant a legume plant that has the ability to survive winter temperatures ranging from 60° to 15° F. or lower and which makes more or less growth during this period.

The term "green manure" used in a strict sense means a crop turned into the soil green or in an immature state for the purpose of soil improvement. A more liberal use of the word, and one that is not uncommon, denotes any crop material left on the surface or turned into the soil, whether in a green or dry state.

A crop grown with the intention of leaving it on the surface rather than turning into the soil is usually called a cover crop, but this term is used more or less interchangeably with green manure.

been determined by detailed tests that the husker-shredder kills a high percentage of the borers contained in the infested stalks. For this reason the husker-shredder has become an important agency in borer destruction.

Success in the use of the husker-shredder, both as a husking machine and for corn-borer control, depends largely upon the care it receives and its handling during operation. Proper handling and care insure greater efficiency of operation, longer life of the machine, fewer delays, and smaller repair bills.

HOW THE HUSKER-SHREDDER OPERATES

When cornstalks are fed into a husker-shredder they are seized by and drawn between the snapping rolls which are held together by spring pressure. As the stalks pass between the rolls the ears are snapped off the stalks and dropped on the husking bed below. The husking rolls then remove the husks and drop the ears into a conveyor which delivers them to the wagon or crib.

The stalks pass from the snapping rolls over a shear bar where the shredding or cutting is done by the revolving head. The shredded stover falls on a shaker where any shelled corn and dirt are removed, after which it is dropped into the blower fan and is blown into the mow or stack. The shelled corn passes over a cleaning screen and then falls through a blast of air into the shelled corn elevator which delivers this corn to the bag or box ready for feeding.

There are, of course, variations in the accomplishment of these operations by the different makes of huskers. This bulletin deals with the principal mechanical features involved in most of the standard husker-shredders now on the market.

HUSKER-SHREDDER UNITS

FEEDER

Three types of feeders are used on husker-shredders, namely, the hand, gravity, and slatted-conveyor feeds. The hand feed was the first type used and is found on many of the 4-roll huskers at the present time. In using this feeder, the operator after cutting the bands of the bundles pushes the stalks forward until they are gripped by the snapping rolls. To do this the operator must work close to the rolls, and for his protection a safety clutch lever, operated by the left leg, is usually provided. This lever should be tried often to be sure of its effectiveness.

The gravity feeder is used on machines having combination snapping and husking rolls. (Fig. 1.) The operator spreads the bundle and lets the stalks slide down into the snapping rolls. With this type of feed there is little danger of injury from the snapping rolls, consequently no safety device is provided.

The conveyor type of feeder is used on all huskers larger than 4-roll that use horizontal snapping rolls. The operator stands facing the snapping rolls with the feed table between himself and the rolls. (Figs. 2, 3 and 4). He spreads the bundle on the conveyor which carries it forward to the rolls. Machines using this type of feeder are equipped with a safety device so that the feeder and snapping rolls may be stopped whenever the operator is in danger or when the husker tends to clog.

SAFETY DEVICES

All safety devices on huskers equipped with the conveyor-type feeder are designed to enable the operator to stop the feeder and the snapping rolls at will. Certain other types of safety devices cause all the moving parts of the machine to stop except the head and the blower fan. Two methods of operating the safety clutches are used. Either a lever is provided within easy reach of the operator (fig. 3), or his weight is required on the feeding platform to keep the clutch engaged. The safety lever often is placed across the front of the feed table so that when the operator leans too far forward the conveyor will be thrown out of gear. Either of these methods is

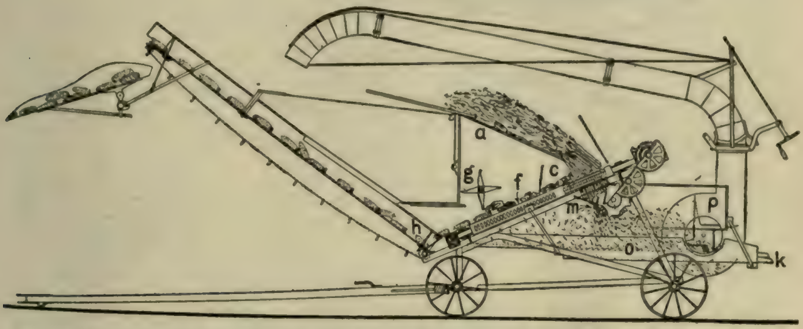

FIGURE 1.—Husker-shredder equipped with gravity-type feeder (*a*); *c, f*, combination snapping and husking rolls; *g*, ear-corn kicker and carrier (*h*); *l*, cutter head; *m*, shear bar; *o*, combination shaker and cleaning shoe using no-choke sieve; *k*, shelled-corn pan; *p*, blower

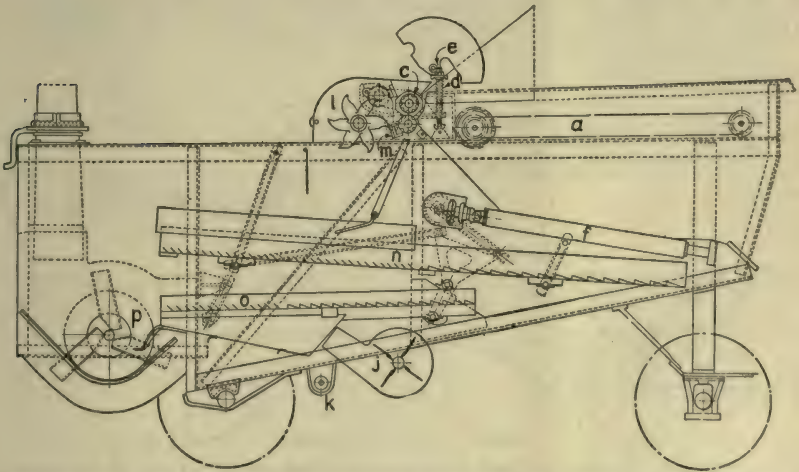

FIGURE 2.—Husker-shredder equipped with conveyor-type feeder (*a*); *c*, horizontal snapping rolls; *d*, snapping-roll springs and adjusting nuts (*e*); *f*, husking rolls; *n*, shaker-type conveyor; *o*, cleaning shoe and fan (*j*); *k*, cross auger; *l*, shredder head; *m*, shear bar; *p*, blower

effective. With the conveyor type of feeder there is little danger of injury to the operator, and the safety clutch is used primarily for stopping and starting, or for stopping when the husker clogs. If the snapping rolls clog the stalks should be dislodged with a softwood stick. One should never reach in with the hands as the clutch may accidentally engage. A hand or an arm is a high price to pay for carelessness.

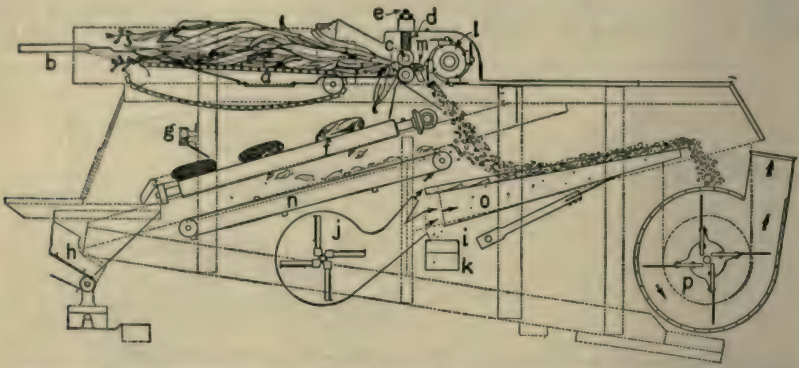

FIGURE 3.—Husker-shredder equipped with conveyor-type feeder (*a*); *b*, safety lever; *c*, horizontal snapping rolls; *d*, snapping-roll springs and adjusting nuts (*e*); *f*, husking rolls; *g*, ear-corn kicker and carrier (*h*); *o*, cleaning shoe and fan (*j*); *i*, *k*, cross shake and screen; *l*, cutter head; *m*, shear bar; *n*, slatted conveyor; *p*, blower

SNAPPING ROLLS

The snapping rolls which operate in pairs pinch the ears off the stalks as the latter are pulled through. The axis of one of the rolls is fixed while that of the other floats under the pressure exerted by the snapping-roll springs. Pressure on the snapping rolls can be varied by the adjusting nuts shown at point *e* in Figures 2 to 5 inclusive. For ease in feeding a low pressure is used on the rolls, especially when the butts of the stalks are wet or frozen. Such an adjust-

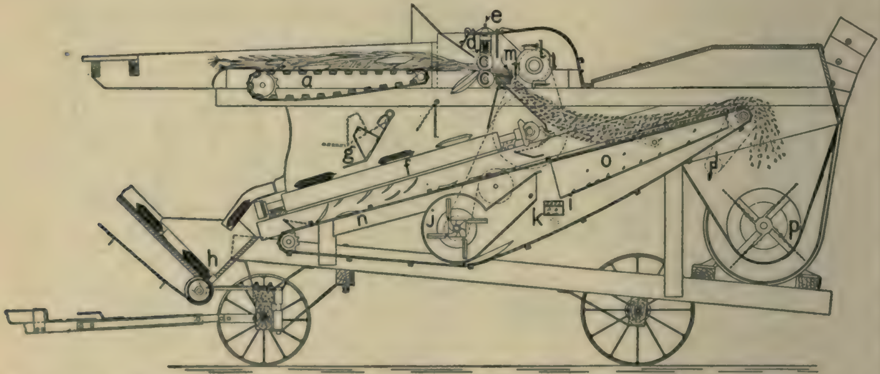

FIGURE 4.—Husker-shredder equipped with conveyor-type feeder (*a*); *c*, horizontal snapping rolls; *d*, snapping-roll springs and adjusting nuts (*e*); *f*, husking rolls; *g*, ear-corn kicker and carrier (*h*); *o*, cleaning shoe and fan (*j*); *i*, *k*, cross shake and screen; *l*, cutter head; *m*, shear bar; *n*, slatted conveyor; *p*, blower

ment is objectionable because an excessive amount of corn is shelled from the ears, and the husker has a tendency to clog.

The number of snapping rolls varies. Some machines have two rolls only (fig. 4), while other machines have two pairs of rolls mounted parallel with the head, one pair above the other. Most huskers having the parallel mounting use only one pair of rolls. These are of the same length as the shredding cylinder. Another common type of mounting consists of two pairs of rolls mounted with their axes at right angles to that of the shredding cylinder and set at an angle of approximately 45° with the horizontal. (Fig. 5.) The third type is the combination rolls, the upper ends of which are used for snapping and the lower ends for husking. (Fig. 1.) This type has gravity feed.

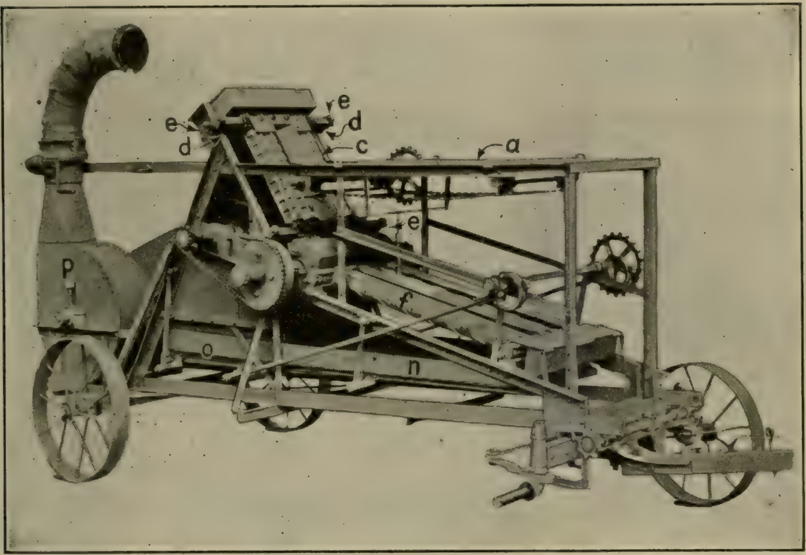

FIGURE 5.—Husker-shredder equipped with conveyor-type feeder (*a*); *c*, vertical snapping rolls; *d*, snapping roll-springs and adjusting nuts (*e*); *f*, husking rolls; *n*, combination shaker-conveyor; *o*, cleaning shoe; *p*, blower

The surface of snapping rolls varies considerably with different makes of huskers. Some have two corrugated rolls working together, some have a corrugated roll and a pitted roll, while others have two pitted rolls. These rolls are timed according to the work being done. The corrugated rolls, for example, may be so timed that the two bars meet, followed by two grooves, or the bar of one roll may meet the groove in the other. The first is the better adjustment for large or frozen stalks, but it has a tendency to shell more corn. For ordinary operation the second adjustment is preferable.

HUSKING ROLLS

A husker-shredder is rated in size according to the number of its husking rolls, which range from 2 to 12. The 4, 6, and 8 roll machines are most common. The husking capacity and power required depend upon the number and size of the husking rolls.

The husking rolls (figs. 2 to 5) are located below and in front of the snapping rolls and operate in pairs. Pegs are inserted in the rolls, which must be so timed that the pegs on one roll of a pair fit into pits on the other as the rolls revolve. The number and size of the pegs used are determined by the condition of the corn. If the husks are tight and are hard to remove, pegs longer than the regular husking pegs may be used. It is possible to insert extra pegs in the husking rolls of many huskers.

Springs hold the husking rolls together. These springs should be so set that the rolls will be held together just tightly enough to grasp the husks and pull them off the ears as they are loosened by the husking pegs. If the rolls are set too tightly, undue wear on the husking-roll bearings will result.

HEAD

The head (*l*, figs. 1 to 5) placed back of the snapping rolls cuts or tears the stalks as they pass through the latter. In machines having a shear bar the head shaft is parallel with the shear bar; in other machines the shaft is parallel with the snapping rolls.

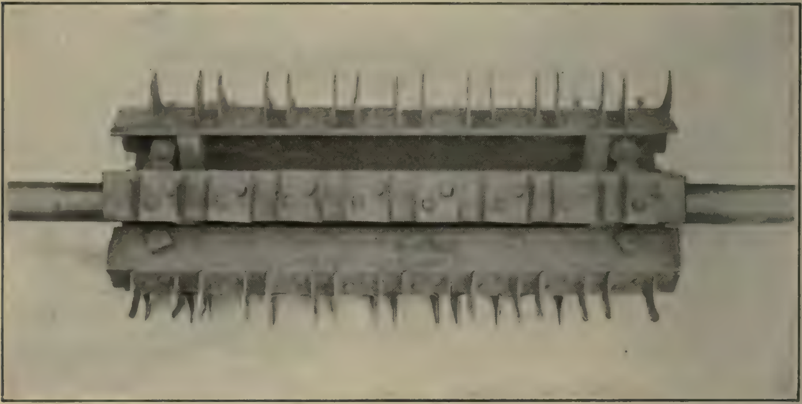

FIGURE 6.—Shredder head showing hooked teeth riveted to angle-iron bars bolted into the head. Six, eight, ten, or twelve bars are used in the shredder head according to the size and make of the husker

Three types of heads are used, the shredder head, the cutter head, and the combination head. The shredder head is fitted with teeth and, as the name indicates, shreds the stalks as they are advanced by the snapping rolls. (Figs. 6, 7, and 8.) The cutter head (figs. 9 and 10) which consists of from one to four knives cuts the stalks into pieces from one-half inch to 4 inches long. The different lengths may be obtained in some machines by changing the number of knives (the greater the number the shorter the cut), and in other machines by changing the gears that drive the feed apron and snapping rolls. The slower the snapping roll speed with respect to the head speed, the shorter the cut. The combination head (figs. 11 to 14) is fitted with both shredder teeth and knives.

The pulley on the head shaft is belted directly to the power unit which operates the husker-shredder, and the speed of the head determines the speed of the other units of the husker. It is important, therefore, to keep the head up to rated speed to insure efficient operation of the machine. The speed of the head is rated by manufacturers in number of revolutions per minute and is indicated on the machine. Shredder heads generally are rated at 1,000, and cutter heads at 750 revolutions per minute, while combination heads vary in speed according to make of machine.

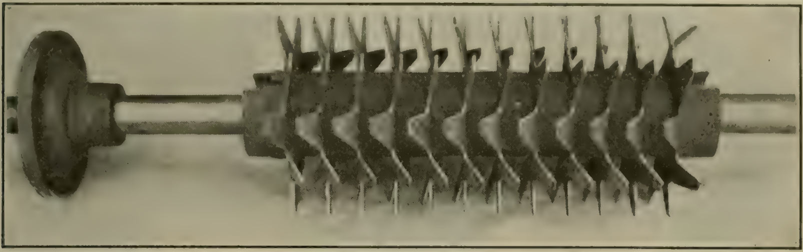

FIGURE 7.—Shredder head with blades stamped out of a steel plate. The teeth are staggered so that every point of the shear bar is covered by a shredder tooth during one revolution of the head

SHEAR BAR

Shear bars, when used on huskers equipped with horizontal rolls, are mounted just back of the lower roll. (Fig. 2 *m*.) On machines using vertical or combination snapping rolls, the shear bar is mounted (fig. 1, *m*) with one edge close to the snapping rolls and the other toward the head. The knives on the cutter head should clear the shear bar about one-sixteenth of an inch. The stalks pass through the snapping rolls, over the shear bar, and are cut or shredded against this bar. To function best, the shear bar should have a sharp working edge. This edge is maintained differently in different machines, as by turning the shear bar over, turning the bar end for end, or replacing it entirely if the bar is not reversible.

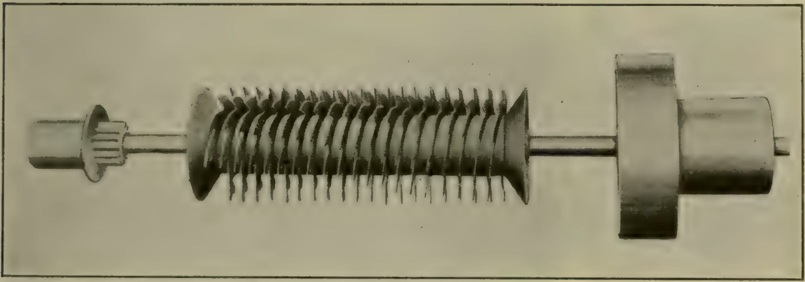

FIGURE 8.—Saw-tooth shredder head. The shredder teeth are stamped steel and are arranged in the form of a spiral. Thus one revolution of the head causes a tooth to pass all points on the shear bar

The shear bar must be used on huskers equipped with cutter heads but may or may not be furnished with shredder heads.

SHELLED-CORN SEPARATING AND CLEANING DEVICES

Some husker-shredders leave a smaller percentage of the live borers in the shredded stover than do others even though the kills may be the same. This is due to differences in the effectiveness of the separating devices. Huskers with characteristics similar to those shown in Figure 2 are effective in separating the borers from the shredded stover. The long shaker with the slat work at the rear end allows the shelled corn, live borers, pieces of cob, and bits of shredded stover to fall through onto the shoe below, where the shelled corn is separated out. Most of the surviving borers remain with the shelled corn because of the fact that when they instinctively curl up their size is about that of a kernel of corn. The shelled corn then passes over a fine screen and into the shelled-corn auger or cross shake. Some of the borers, however, go through this screen and are found on the ground under the machine.

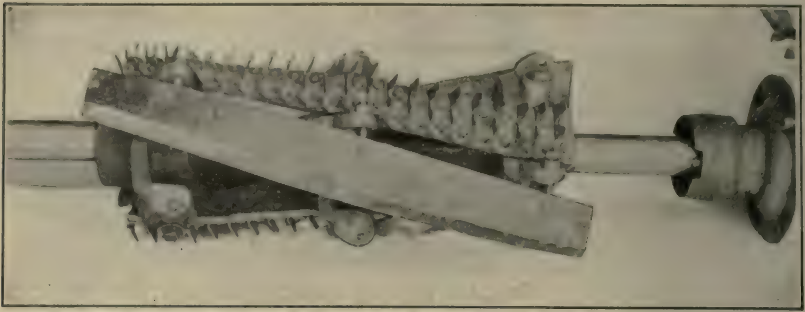

FIGURE 9.—A cutter head equipped with four full blades. This head may be operated using two blades, one on each side of the head, or using one blade with counterbalances on the opposite side of the head

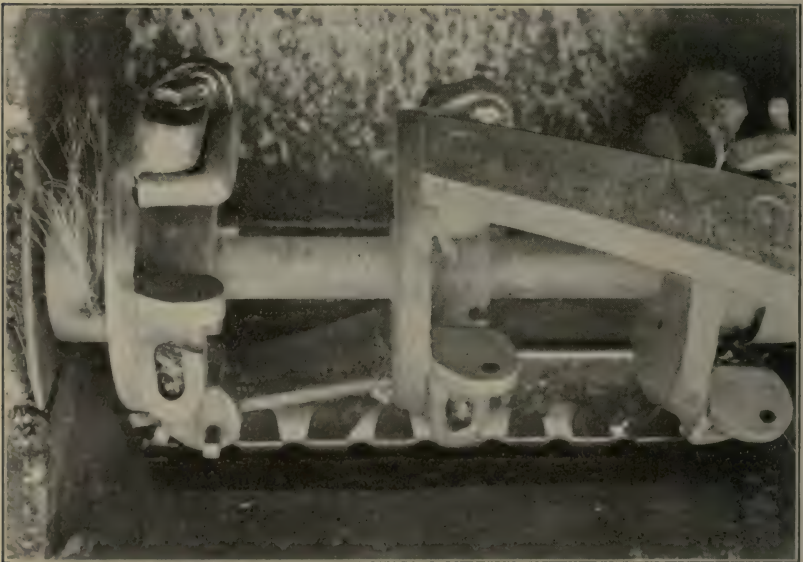

FIGURE 10.—Cutter head in position equipped with two half-knives. The claim is made that two half-knives set up less vibration than one full knife with counterbalances

Figures 1 and 5 show two types of huskers which use a single shaker running the entire length of the machine. The front part of the shaker is made of corrugated steel fitted with riveted-on-fish-backs to carry the husks and pieces of stalk back from under the husking rolls. The shaker has a no-choke sieve extending from a point under the head to the rear end of the machine. This allows the shelled corn, live borers, and other material to drop on the bottom below. The shaking motion causes the corn to move to the rear of the machine, pass over a fine screen, and to come out at the rear end.

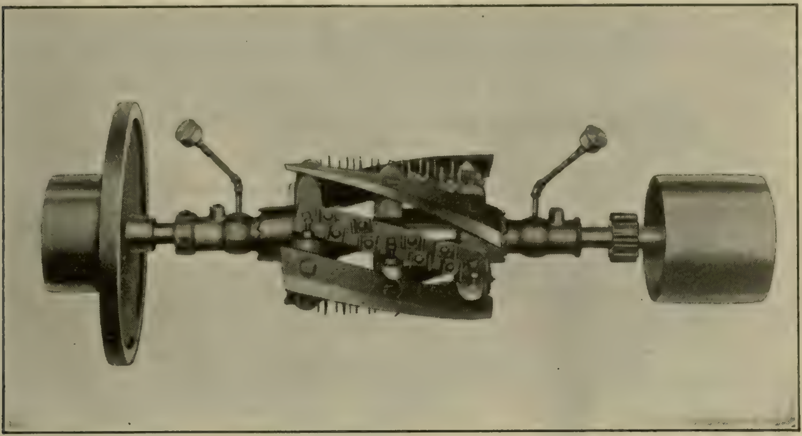

FIGURE 11.—A combination head equipped with four knives and four shredder bars. It is possible to equip this type of head with 2 or 4 knives, 2 or 4 shredder bars, or combination of 2 or 4 knives with 2 or 4 shredder bars

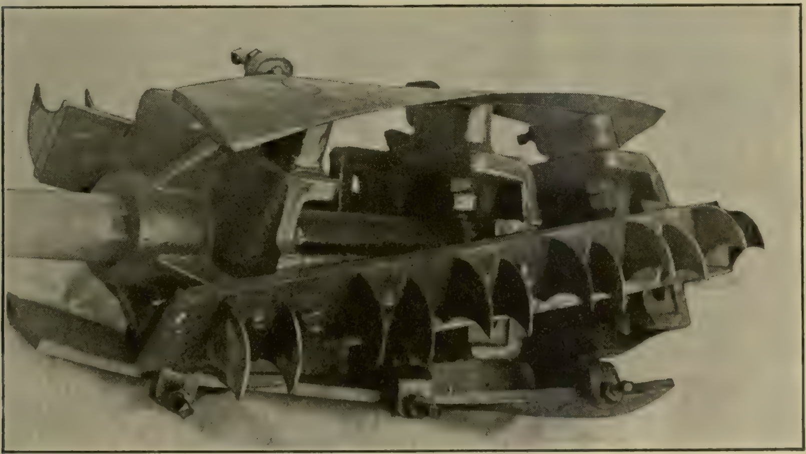

FIGURE 12.—Combination head equipped with two shredder bars and two knives. This head may be converted into a 2-knife head by removing the shredder bars, or into a 4-knife head by replacing the shredder bars with knives

Two other types of separating devices are shown in Figures 3 and 4. Both have the slatted-chain conveyor to move the husks back from under the husking rolls. The machine shown in Figure 3 has a separator made up of a no-choke sieve with a sheet-iron bottom starting below the head and continuing to the rear. The shelled corn and some of the live borers are shaken out and fall on this bottom, then slide down into the cross shake. In the machine shown in Figure 4 the slatted chain continues back over the shaker and returns under the machine. The shaker has a perforated top and vibrates under the conveyor. The cross shake on these huskers has a screen bottom which separates most of the dirt from the shelled corn before delivering the corn to the bag.

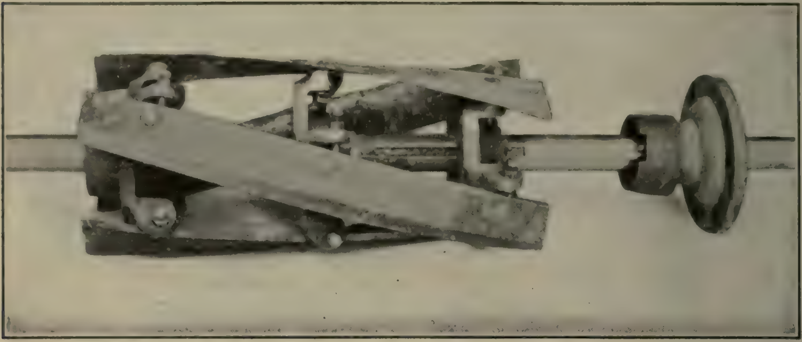

FIGURE 13.—Combination head equipped with two knives and two shredder bars

BLOWER

The blower unit (*p*, figs. 1 to 5) delivers the shredded or cut stover to the mow, shed, or stack. When shredding, the hood on the end of the blower pipe should be moved from time to time to distribute the stover evenly over the pile. This prevents the heavy, moist pieces from piling up in one place and thus causing spoilage of stover. Care should be taken to maintain proper speed of the blower, otherwise clogging may result.

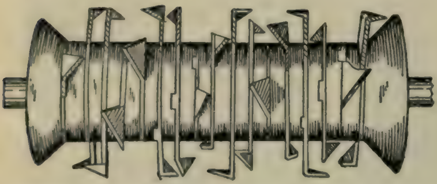

FIGURE 14.—Combination head made to operate in a husker without a shear bar. The triangular-shaped end on these shredder knives is sharpened so that it cuts the stalks. The edge of the blade from the knife section to the spacer rings has a serrated edge that tends to shred the stalks

TRANSPORT TRUCK

Four-roll or larger husker-shredders are equipped with 4-wheel transport trucks. (Figs. 4 and 5.) The rear wheels are mounted on a plain, dead axle. Two types of front axles are used, the pivot or auto type axle and the fifth-wheel or wagon type. There is less tongue whipping with the pivot axle, but this factor is of little consequence when the machine is moved with a tractor.

CARE OF HUSKER-SHREDDER

PREPARATION FOR THE SEASON'S WORK

The preparation of the husker for the coming season's work may start as soon as the work of the previous season is finished. Any new parts needed should be ordered early because of possible delays in shipment. Every nut should be tried and tightened if necessary. The knives should be sharpened if the cutter head is to be used, or the teeth straightened if the shredder head is employed. If the edge of the shear bar is rounded badly a new edge should be applied. While all bearings should be adjusted to remove any lost motion, in doing this care must be used not to cause binding and consequent heating. Each shaft should turn easily by hand. Broken slats in machines having slatted shakers should be replaced, and bent lips on the shaker having the no-choke sieve should be straightened. Any broken boards in wood-frame huskers should be replaced and any dents in the steel housings taken out. Belts should be examined and repaired, and replaced where necessary. A belt lacing in the condition shown in Figure 15 is dangerous to the operator and likely to result in delays at a busy time. Broken or badly worn chain links should be replaced.

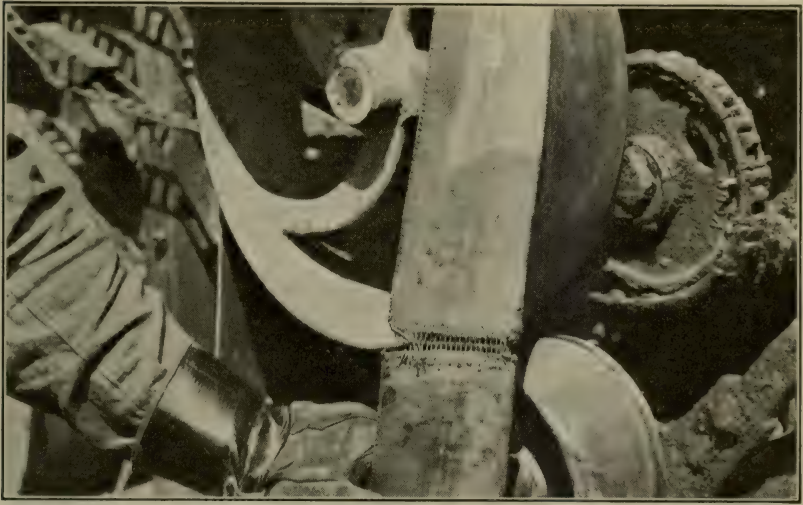

FIGURE 15.—Belt lacings in this condition should be repaired to prevent the end of belt tearing out

Any repairs made during the off season will save time and trouble when husking time arrives. The operator should make a practice of having his husker in the best possible condition at the beginning of each season. His husker will then last longer, and if custom work is done his customers will be better satisfied if he is able to operate continuously whenever the weather is favorable.

CARE DURING OPERATION

The operator of any power-driven machine should become accustomed to its normal sound. This is especially important in the case of a machine that performs a number of operations, such as the husker-shredder. Any unusual noise should be investigated immediately. A knife or shredder bar may work loose. This should be located and the bar tightened immediately. (Fig. 16.) Prompt tightening of a loose knife may prevent damage to the head and its supporting casting. The repairs needed in case of an accident of this type are expensive.

Serious damage may further result from undetected stones or other hard material fed with the stalks into the husker. In such a case an emergency stop should be made immediately and the foreign material removed. Even though the snapping rolls or the head may have escaped damage the blower unit would be subject to damage.

All bolts on the husker should be checked periodically. Many of them can be checked on days when it is not possible to husk, but especial attention should be given to the head bolts and those holding the shear bar, and main bearing caps. Particularly should the head bolts be checked often after knives or shredder bars have been changed. The operator may check the tightness of the bolts in the head of his machine a dozen or more times without finding a loose bolt, but if he should find one at the next inspection he will have been repaid for all his effort.

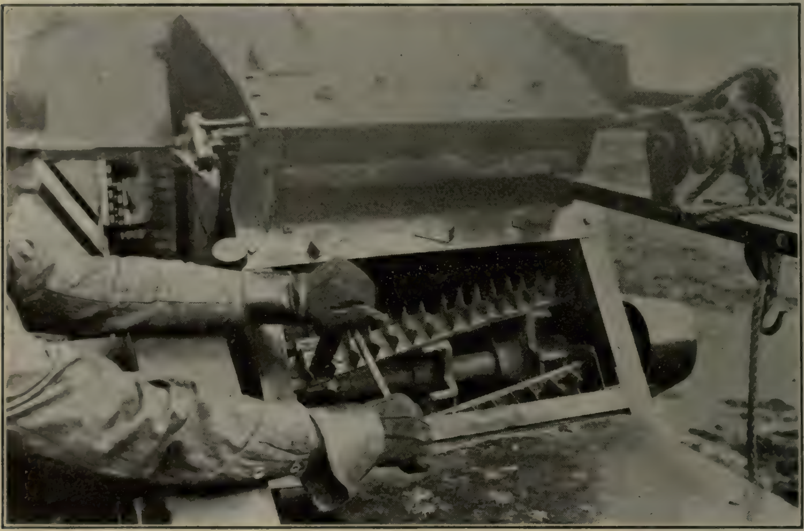

FIGURE 16.—Head bolts should be checked periodically, especially after knives or shredder bars have been changed

The knives on the cutter head should be kept sharp. This will save power and will reduce the strain on the husker. The clearance between the knives and shear bar should be adjusted carefully and kept at about one-sixteenth of an inch, although for corn-borer control a slightly greater clearance is more effective. Care should be taken to have the clearance sufficient to prevent any possibility of a knife catching on the shear bar.

Before engaging the tractor clutch, particularly in cold weather, the husker should be turned by hand to see that all parts are free. If some of the parts are frozen together a little hot water will loosen them. Snow and ice often lodge around the snapping rolls and cause the lower roll to freeze to the shear bar. Another common trouble is the freezing down of the conveyor feeder. If there is snow or ice in the butts of the stalks, when stopping work the clean-out doors at the lower end of the shelled-corn elevator and other elevators should be opened and all snow and slush removed.

The husker is generally set up just outside the barn, where it remains until the job is finished. Here it receives some protection from high winds, while the end of the blower, being inside the barn, is protected against snow and rain. If, however, the blower pipe is exposed to the weather it should be lowered at night, placed on the transport bracket, and the end covered. The feeder and feeding gears should likewise be covered each night so as to prevent the freezing down of the conveyor chain and the snapping rolls in the event of bad weather. Belts should be covered, or removed and put in a dry place.

PREPARATION FOR STORAGE

At the end of the husking season the machine should be carefully prepared for storage. First clean the machine thoroughly both inside and out, and then grease all bright metal parts to prevent rusting. The head parts, snapping and husking rolls, blower fans and metal fodder chute leading to the blower, should be given especial attention. Any wooden parts showing signs of weathering should be painted with a good grade of paint. The entire machine should be painted at intervals depending upon the weathering it receives. The old grease and oil should be washed out of the bearings to dispose of any dirt or grit that may have accumulated, and replaced with fresh materials. A list should be made of all parts that need replacing for the next season's runs, and any minor repairs or adjustments needed should be noted.

Often the husker-shredder may be stored to better advantage by removing some of its parts. A space otherwise too small may be used if this is done. The shed that houses the husker should have good side walls and a roof free from leaks. If the floor is of dirt or cinders, it should be fairly level and well drained, and boards should be placed under the truck wheels.

BELTS AND CHAINS

Belts supplied on husker-shredders usually are of waterproof rubber composition and require very little attention. They should, however, be run with the smooth side next to the pulley, otherwise the rib will be worn away and the life of this belt shortened. Sometimes leather or canvas belts are used. Leather belts should be run with the hair (smooth) side next to the pulleys, while either side of a canvas belt may be next to the pulleys. To obtain maximum service from canvas and leather belts they should be protected from moisture and treated to keep them soft and pliable. Neatsfoot oil should be used on leather belts and a good belt dressing on canvas belts. Never use a mineral oil on belts.

Belts should be run just tight enough to prevent slipping and flapping, but not so tight as to set up excessive strains in the shafts and cause heating of the bearings. Wiping the inside of a new rubber belt with a damp cloth to remove the powder will reduce its slippage. When belting up a machine, damage to the belt may be prevented by turning the belt on to the pulley rather than resorting to hammering or prying.

Detachable link chains should be run as shown in Figure 17. Otherwise there is a tendency for the pull of the load to close the hook on the links and cause them to bind. Roller chains, which are used on the heavier drives of some huskers, require a good grade of machine or engine oil. While roller chains are usually shielded from dirt they should nevertheless be cleaned periodically. To clean them, they should be removed, rinsed in gasoline or kerosene, dried, and dipped in an oil bath. Detachable-link chains may be lubricated with engine oil or cup grease. Chains should be kept tight enough to permit of only slight sag.

LUBRICATION

An important consideration in the care of any machine is its lubrication, the purpose of which is to reduce friction between moving surfaces and thus prevent unnecessary wear. An oil film must be maintained between these surfaces; this is accomplished by one of the following methods commonly used on machines of the husker-shredder type: (1) Wick oilers; (2) grease cups; (3) pressure lubrication.

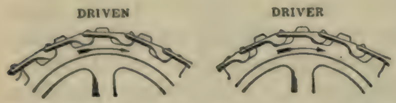

FIGURE 17.—The hooks on chain links must be on the outside and run forward

Where wick oilers are used engine oil or a good grade of machine oil should be used. The wicking in the cups or wells should be kept loosened so that a sufficient flow of oil to the bearings will be maintained. A soft cup grease is used when either the grease cup or the pressure system is provided. A grease cup is filled and screwed down until the grease starts out of the end of the bearing. This not only insures complete lubrication, but also forces out any dirt or grit that may have collected. If the pressure system is used, grease coming out of the end or other parts of the bearing is reasonably good evidence that the part is thoroughly greased.

The head shaft, blower shaft, and snapping-roll shafts operate at high speed and under high bearing pressure; hence to insure thorough lubrication they should be greased at least three times during each half-day's run. The husking-roll bearings, the bearings on the shelled-corn cleaning fan, and the gearing that drives the snapping rolls and feeder should be oiled at least once during a half-day's run. The pitman bearings can not be oiled while the husker is in operation but should be thoroughly oiled before starting each half-day's run. The transport trucks should be greater every 50 or 60 miles. Always use engine oil or a good grade of machine oil. Avoid the use of used crankcase oil, since it has little body and contains much grit and dirt. Never use axle grease in grease cups. Keep all oil and grease supplies free from dirt.

The husker-shredder is used in the fall and winter when an oil becomes thick and does not flow readily. The oil may be warmed by the heat of the tractor and thus caused to flow from the can, but it may thicken on contact with the cold bearing caps and other parts, and cause inadequate lubrication. Under these conditions use an oil that is thin enough to flow quite freely when cold. In extremely cold weather it may be necessary to mix kerosene with the oil to give it the required fluidity.

OPERATION AND ADJUSTMENT FOR CORN-BORER CONTROL

In areas infested with the European corn borer the husker-shredder has proved to be very effective in destroying borers. Tests have shown that with proper adjustment and careful operation, kills of from 95 to 98 per cent of the borers can be made. Most of the borers are killed while passing between the snapping rolls, but the mortality is increased by the action of the head, and probably still further by contact with the blades of the blower fan. The effectiveness of the shredder head, the combination head, and the knife head cutting lengths of 2 inches or less, is about the same.

EFFECT OF SNAPPING-ROLL PRESSURE ON THE PERCENTAGE OF BORERS KILLED

Snapping rolls alone, properly adjusted, kill from 80 to 90 per cent of borers in the stalks, the highest kills being obtained when the pressure on the rolls is greatest. There is a direct relationship in all types of huskers between pressures on the snapping rolls up to 1,000 pounds, and the percentage of borers killed. Tests have shown that the kill is raised approximately 6 per cent by increasing the pressure on the snapping rolls from 400 pounds to 1,000 pounds, but that the mortality is only slightly further increased with pressures in excess of 1,000 pounds.

LIVE BORERS IN SHREDDED STOVER

Some of the borers surviving the snapping rolls and the cutter or shredder head are shaken out of the stover and deposited in the shelled corn, or on the ground under the machine, where they can be easily destroyed by methods described later. The living borers remaining in the stover are blown into the mow. Repeated tests have shown that practically all such borers are destroyed ultimately by (1) injuries received while passing through the husker, (2) drying out of the fodder, (3) being fed to livestock, or (4) being trampled into the manure, incident to the feeding of the shredded stover or its use as bedding.

It has been found by experiment that the higher percentages of live borers are left in the stover when the lower snapping-roll pressures are used. Thus it can be assumed that any adjustment of the snapping rolls and head that will give the highest kill will also tend to leave the smallest percentage of the borers alive in the shredded stover. As shown in Table 1, knife heads that cut the stover in 4-inch lengths leave the highest percentage of the borers alive in the cut stover, and those making ½-inch cuts leave the lowest percentage.

Table 1.—*Relation between the lengths of cut, per cent of borers killed, and per cent of borers left alive in the cut stover*

Length of cut	Borers killed	Borers left alive in cut stover
Inches	*Per cent*	*Per cent*
4	93.2	4.5
2	95.0	2.1
1	96.4	.6
½	98.0	.5

LIVE BORERS IN SHELLED CORN AND UNDER HUSKER

The borers left alive in the shelled corn by the husker can best be killed by feeding the corn to chickens or hogs. This shelled corn never should be mixed with the ear corn as the live borers would then be able to bore into the pith of the cobs where, being protected, they might complete their life cycle. The shelled corn should be fed in a trough or on a tight feed floor where the borers will be picked up before they can obtain shelter by crawling into straw, corncobs, or other material. If the corn is not to be fed, it should be treated in such a way as to kill the borers. This may be done by grinding, or by heating it to 160° F. and keeping it at this temperature for at least five minutes.

After the completion of the work at each set-up the material on the ground under the husker-shredder should be carefully collected and burned to kill the borers that may have been missed.

EFFECT OF SPEED OF HEAD ON PERCENTAGE OF BORERS KILLED

The percentage of borers killed varies directly with the speed at which the machine is operated up to normal speed, when the kill is at a maximum. Usually this is 1,000 revolutions per minute for the shredder head, and 750 to 850 revolutions per minute for knife or cutter heads. Running the head at 20 per cent below rated speed was found to decrease the kill of borers from 2 to 3.5 per cent, and to increase the percentage of borers left alive in the shredded stover when either a shredder head or a combination head was used.

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U. S. GOVERNMENT PRINTING OFFICE: 1931

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1663

WINTER LEGUMES for GREEN MANURE in the Cotton Belt

THE USE OF WINTER LEGUMES for green manure in the Cotton Belt has greatly increased in recent years. Austrian winter peas, hairy vetch, and smooth vetch are the crops most used, while crimson clover, bur clover, and sour clover are used in limited areas.

A legume green-manure crop reduces erosion and also the leaching of plant food. It improves the physical condition of the soil by the addition of organic matter and through the nitrogen-gathering bacteria adds plant food. It also increases yields of subsequent crops grown with it in rotation.

Winter legumes should be inoculated at the time of seeding. Commercial fertilizer consisting largely of superphosphate should be used, especially when growing a legume crop on land for the first time. Barnyard manure also increases the growth of winter legumes and greatly aids in getting the plants inoculated.

Seedings should be made the latter part of September or early in October. Earlier seeding may result in injury by nematodes, and later plantings often result in poor stands and growth.

The green-manure crop should be turned under two weeks preceding planting corn and three weeks before planting cotton.

Washington, D. C. **Issued April, 1931**

WINTER LEGUMES FOR GREEN MANURE IN THE COTTON BELT

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INTRODUCTION

THE USE of winter legumes for green manure in the Cotton Belt has greatly increased in recent years, largely on account of demonstrations by the State and Federal experiment stations and the practical experience of farmers. The value of this practice and the best crops for the purpose have been indicated by these experiments.

By legume is meant a plant that bears pods like the pea or the bean. These pods are 1-celled and usually split in two pieces.

By winter legume is meant a legume plant that has the ability to survive winter temperatures ranging from 60° to 15° F. or lower and which makes more or less growth during this period.

The term "green manure" used in a strict sense means a crop turned into the soil green or in an immature state for the purpose of soil improvement. A more liberal use of the word, and one that is not uncommon, denotes any crop material left on the surface or turned into the soil, whether in a green or dry state.

A crop grown with the intention of leaving it on the surface rather than turning into the soil is usually called a cover crop, but this term is used more or less interchangeably with green manure.

LEGUMES NOW COMMONLY USED

There are six winter legumes now used for green manure more or less commonly in the Southern States. These are hairy vetch, smooth vetch, Austrian winter pea, crimson clover, bur clover, and sour clover. The region to which sour clover has proved adapted is confined to Arizona, the Delta area of Louisiana and adjoining States, and to the black lands of Alabama and Mississippi.

Crimson clover is best adapted to the more northern part of the Cotton Belt and is now grown most extensively in the region east of the Blue Ridge Mountains from northern Alabama and Georgia north to New Jersey.

Bur clover is very generally used throughout the South except on the real sandy lands, while Austrian winter peas, smooth vetch, and hairy vetch seem to be universally adapted and are the crops most commonly used.

There are no definite figures indicating the acreage of winter legumes used for green manure in the Cotton Belt. Estimates have been made from the amount of seed known to have been shipped into the several States, and figures have been compiled in a few States from county agents' reports and from such other sources as were available. It is estimated that the total acreage of winter legumes planted in the Cotton Belt in 1928 was about 150,000 acres, and in 1929 about 250,000. The total acreage planted for green manure would be much above these figures, as a large amount of rye is used each year for this purpose.

VALUE OF GREEN MANURES

A number of reasons are commonly advanced for the use of green-manure crops. Some of these are based on very obvious facts, while others are less apparent.

In regions where soils wash badly a growing crop on the land during the season of heavy rainfall will prevent much washing. It is well known that soils containing a high percentage of organic matter will wash less than those low in organic matter. Thus a green-manure crop will prevent much washing both during the period of its growth and for the time that it increases the organic content of the soil.

With the addition of organic matter there is usually an improvement in the physical condition of the soil. This is noticeable in its increased moisture-holding capacity and the ease with which the soil can be worked when plowing or disking.

In addition to improving the physical condition and preventing washing, a winter green-manure crop prevents leaching of plant food during the winter season. When there is no growing crop on the land the plant-food elements that become available through decomposition or otherwise are lost. When a growing crop is on the land these elements are taken up by the crop and again made available when it is turned into the soil. In this way a green-manure crop conserves fertilizer. When a legume crop is used for green manure it not only takes up the plant food that otherwise would leach from the soil, but it also adds nitrogen that it takes directly from the air through the symbiotic bacteria on its roots.

A fertile soil has a large number of microorganisms. In order that these may flourish it is essential that organic matter be supplied to the soil. Organic matter also has an effect on the mineral elements of the soil and aids in making them available as plant food.

It has long been recognized that legumes in rotation with nonlegumes are beneficial to the latter. Nonlegumes in continuous culture give smaller yields than are obtained from nonlegumes in rotation with legumes. This increase is due in great part to the nitrogen that the legume takes from the air, but aside from this there appears to be a beneficial effect due to other unexplained factors which persist after the fertilizing material of the plant has disappeared.

The net results accruing from the use of winter legumes are increased yield of the crop that immediately follows and lessened but noticeable increases in succeeding crops for several years.

INOCULATION

Under Cotton Belt conditions all winter legumes need to be inoculated with nitrogen-fixing bacteria. This can be accomplished by the use of commercially available pure cultures, directions for which will be found on the package, or by the use of soil from a field that has recently grown the crop which it is desired to inoculate.

When soil is used it can be mixed with the seed at the rate of a half bushel or more per acre and be drilled with a 3-row drill or with a "knocker" fertilizer distributor. The soil should be dried and sifted to make it run freely, or it can be applied broadcast at the rate of 1,000 pounds per acre and be worked into the soil ahead of seeding. Many farmers think it is good insurance to use both the commercial culture and soil.

One of the most essential things in inducing inoculation and good subsequent growth of winter legumes is the use of fertilizers. Commercial fertilizer, unless it is basic slag, should not come in contact with inoculated seed as it may injure the inoculating organism; however, a general application of fertilizer preceding or at the time of seeding is essential to success. If the summer crop preceding the winter legume has been well fertilized, the quantity applied to the winter-legume crop can be greatly reduced or in some cases entirely omitted.

When the winter legume is to be planted on lands where it has not grown previously, and following a summer crop that has been but lightly fertilized, the use of superphosphate will help the inoculation.

Barnyard manure is very effective in inducing inoculation and should be used whenever available.

FERTILIZERS

The successful growing of a green-manure crop on the poorer lands of the South requires the use of commercial fertilizer. Of the common fertilizer constituents phosphoric acid is usually the most needed; however, on the poorer lands the addition of nitrogen will help very materially, and this should be used until a winter-legume green-manure crop has been grown successfully. The fertilizer should be applied in the fall just prior to, or at the time of seeding the green-manure crop.

The amount of fertilizer used will vary with soil and cropping conditions. When the summer crop preceding the winter legume is heavily fertilized, little, if any, fertilizer will be needed on the winter legume. If the soil is poor and the summer application of fertilizer is light, the use of 200 pounds or more of superphosphate, or 300 of basic slag and 50 pounds of sodium nitrate or ammonium sulphate or an equivalent nitrate fertilizer is advisable. When growing a winter legume for the first time on land that has been but moderately fertilized it is advisable to use as much as 400 pounds of superphosphate or 600 of basic slag per acre and 100 pounds of a nitrate fertilizer.

Lime at the rate of 1 to 2 tons per acre is used occasionally in addition to the fertilizers previously mentioned, and increased yields have sometimes followed this practice.

PREPARATION OF THE SEED BED

The largest acreage of winter legumes follows cotton, in which case little or no preparation of the soil is necessary. This is also the case where the winter legumes are preceded by cowpeas, soybeans, or Spanish peanuts. Under such conditions the seed is sown broadcast and disked in, provided the previous crop has been harvested sufficiently early. A crop of tobacco or melons may also be followed by winter legumes using the same method. If for any reason the land needs flat breaking the preparation is more expensive and requires more time.

On clayey soils where there is considerable weed growth or the soil is packed hard, plowing or heavy disking will be essential in order to give a good seed bed. In the case of crops with large seeds like field peas there is little danger of covering the seed too deep but in the case of crops with small seeds like crimson clover it is necessary for best results to work the soil down into a firm condition before seeding.

SEEDING

The best time for seeding will vary with latitude and seasonal conditions, but in general seeding should be done if possible during the last half of September in the northern part of the Cotton Belt, and early in October in the southern part. Early seeding is desirable in order to get as much fall growth as possible, but where nematodes are numerous early seedings may be seriously damaged. In general, seedings made about the first of October escape with but little nematode injury. In severe winters, however, seedings made as late as the first of December will usually result in poor stands due to winterkilling, and but little growth will be made by the time the crop should be turned down for corn or cotton. Results at the Alabama Agricultural Experiment Station show that winter legumes planted October 1 made twice the yield by April 1 of the next year as the planting made November 1.

The quantity of seed needed to give a good stand has been reasonably well determined by experimental work. Local variations in the soil, preparation of the seed bed, etc., are factors influencing the rate of seeding, but in general the range of variation in the quantity needed is not great.

The quantity of seed per acre that is considered advisable under average Cotton Belt conditions is shown herewith. Farther north or where winterkilling and other factors tend to reduce the stand more seed is recommended. When a seed drill is used a smaller quantity of seed is required than when the seed is broadcast, and thoroughly prepared land requires less seed than land that is rough and poorly prepared. Under favorable conditions the least quantity of seed indicated can be used, while under less favorable conditions the quantity should be increased accordingly.

QUANTITY OF SEED TO USE PER ACRE

Fenugreek (*Trigonella foenumgraecum*)	pounds	20–30
Hairy vetch (*Vicia villosa*)	do	20–30
Smooth vetch (*Vicia villosa* var.)	do	20–30
Narrowleaf vetch (*Vicia angustifolia*)	do	20–30
Woollypod vetch (*Vicia dasycarpa*)	do	25–35
Monantha vetch (*Vicia monantha*)	do	30–40
Austrian winter pea (*Pisum arvense*)	do	30–40
Common vetch, Oregon (*Vicia sativa*)	do	40–50
Hungarian vetch (*Vicia pannonica*)	do	40–50
Purple vetch (*Vicia atropurpurea*)	do	40–50
Bard vetch (*Vicia calcarata*)	do	40–50
Bittervetch (*Vicia ervilia*)	do	40–50
Tangier pea (*Lathyrus tingitanus*)	do	60–70
Horse bean (*Vicia faba*)	do	60–90
Yellow lupine (*Lupinus luteus*)	do	60–80
Blue lupine (*Lupinus hirsutus*)	do	60–80
Black medic (*Medicago lupulina*)	do	10–15
Sour clover (*Melilotus indica*)	do	15–20
Crimson clover (*Trifolium incarnatum*)	do	15–20
Southern bur clover (*Medicago arabica*) (unhulled)	bushels	5–6
Tifton bur clover (*Medicago rigidula*) do	do	4–5
California bur clover (*Medicago hispida*)	pounds	15–20
Serradella (*Ornithopus sativus*)	do	15–20

The seed may be sown broadcast or with a drill in cotton middles. If broadcast, the seed may be covered with a 1-horse plow or cultivator or with a 2-horse cultivator that straddles the row and has disks or plows that do a good job of covering. If drilled, the 3-row 1-horse drill serves the purpose, but the middle hole may be closed, because the crop does not grow well in the center of the row especially where the middle is low. For vetch the sorghum plate should be used, but winter peas need a larger plate. Some farmers go twice to the row with a 1-row drill or with a fertilizer distributor that sows a mixture of seed, soil, and basic slag. Superphosphate is not mixed in this way, because of danger of killing the inoculation.

To avoid injury to the cotton, the drilling should be done immediately after a picking. In the lower part of the Cotton Belt the cotton is picked out before the winter legumes are planted. Where conditions permit the use of larger drills, they save much time in planting the crop.

Short and narrow plows on the 1-horse drills make only a small furrow, but even this should be filled with a smoothing attachment, such as a scratcher, chains, or a small chain harrow. This is particularly necessary for vetch, because the young plants flatten out on the ground, and the first heavy rain washes the dirt and sand in on them. This danger is greater on sandy lands.

Drilling when properly done gives a larger yield of green-manure crop than broadcasting, just as it does with small grains. There is also less "heaving" of plants in freezing-thawing weather on clay soils if the drill is used.

TURNING UNDER

When should a green-manure crop be plowed under for a spring-planted crop? This is a question that can be answered only in a general way. If done too early it will have too little fertilizer value, and if done too late the heavy growth will be difficult to turn under and cover properly, or the evaporation of moisture through the leaves of the plants may have pumped the moisture from the soil, leaving it hard and dry. Also, if the crop is hairy or smooth vetch there is danger of injury from vetch worms (same as corn ear worms) after the pods begin to form.

When the weight of green vetch is 12 pounds per square of 10 by 10 feet, the nitrogen in it, calculated to an acre basis, is equivalent to about 300 pounds of nitrate of soda. For Austrian winter peas 14 pounds will have nearly the same nitrogen equivalent. This is sufficient for a good crop of corn and ordinarily ought to be plowed in without further waiting. To delay turning beyond this point in order to get 50 to 100 per cent more nitrogen means running risks of dry weather, of unwieldy growth, of greater difficulties in getting stands of corn, and of possible inqury from vetch worms. In their zeal to get the maximum quantity of nitrogen many farmers wait too long and run into difficulties they do not foresee.

When the growth is at the stage mentioned, it can be turned under with an ordinary 2-horse plow with a 12-inch rolling colter attached. If the growth is very heavy, larger plows and more power will be needed. The 3-horse sulky plow with rolling colter is an excellent implement for the purpose. Tractor plows, whether of disk or moldboard type, will do the job.

It is known that the rate of decomposition of vegetable matter in the soil varies with changes in temperature and moisture, and aside from these factors one must take into consideration the stage of maturity of the green-manure crop. An immature crop decomposes more rapidly than a mature crop, and allowance for this must be made. Experimental work has indicated that a green succulent winter-legume crop should be turned down about two weeks before planting corn and three weeks before planting cotton. In the case of tree crops the time of active growth of the tree can perhaps be used as a good guide for turning down or otherwise disposing of the green-manure crop. Decomposition should take place just preceding and during active growth of the tree. In this connection it should be remembered that with average spring conditions a succulent green-manure crop turned into the soil decomposes and practically disappears in from six to eight weeks. A mature crop decomposes somewhat more slowly, and when the crop is worked into the soil lightly or is left on the surface as a mulch the period of decomposition is extended accordingly.

PREPARING LAND FOR SUBSEQUENT CROPS

Most of the winter-legume land is broken flat in the spring and harrowed soon after. Then after a wait of about two weeks it is listed and corn is planted in the water furrows, though sometimes the land is leveled and the crop is planted on the level. Sometimes it is "hard bedded," which means that two furrows are thrown together at intervals of 4 feet, or whatever the width of row happens to be, then the ridge left in the middles is plowed out with a turnplow, and corn is planted immediately in the water furrow. This method is better adapted to sandy lands than to clay. One advantage of this method is that corn can be planted without waiting for the legume to decay, but whether, in the long run, it is advisable to do so is still an open question.

In preparing winter-legume land for cotton it is flat broken and then, after a wait of three weeks or thereabouts, low beds are prepared and the cotton is planted in the usual way.

VOLUNTEERING A WINTER LEGUME

Few winter legumes will mature seed under Cotton Belt conditions and have enough hard seed to carry over and give a good volunteer stand the following year. The bur clovers can be handled in this manner quite successfully when the planting period of the succeeding crop can be delayed until late spring so that some seed will have matured. It is also possible to leave strips of the bur clover undisturbed at the time of planting the summer crop, with the idea of cultivating or turning down these strips after the bur-clover seed has matured and in this manner provide seed for the succeeding volunteer crop.

Narrowleaf vetch matures seed early and volunteers readily in waste places throughout the South, but this plant has never been handled successfully in pure stands under cultivation.

Hairy vetch under favorable conditions will mature enough seed to volunteer, but the comparatively late season of maturing and the likely damage by the corn ear worm usually makes the volunteering of this crop inadvisable.

All the other common winter legumes either fail to mature enough seed under southern conditions or lack sufficient hard seed to serve as volunteer crops.

YIELDS OF GREEN MANURE

The yield of any winter green-manure crop will vary with seasons, with different soils, and with other local conditions. This is especially true when the green-manure crop must be turned down early in order to be out of the way for a succeeding summer crop.

It is desirable to have a large green-manure crop yield, and in determining the time of planting and the crop to use this should be given first consideration.

In Table 1 is given the green weight of hairy vetch and peas as grown in connection with experimental work at Tifton, Ga., and Gainesville, Fla.

Yields based on air-dry weights and reported from the Alabama Agricultural Experiment Station at Auburn for the 5-year period 1925 to 1929, inclusive, when planted October 1 and November 1, respectively, and harvested at the same date in early spring, are as follows: Austrian winter peas planted October 1, 3,317 pounds, and planted November 1, 2,418 pounds; hairy vetch planted October 1, 3,271 pounds, and planted November 1, 2,476 pounds. At Clemson College, S. C., for the period from October 1, 1926, to February 12, 1927, hairy vetch yielded 2,190 pounds dry matter and Austrian winter peas 6,620 pounds. The green weight probably would be about five times the dry weight.

Yields of Austrian winter peas and hairy vetch in pecan groves in Florida ranged from 10,000 to 20,000 pounds green weight. Other general data available indicate that a wide range in yield may be expected.

TABLE 1.—*Yields per acre of hairy vetch and Austrian winter peas at Tifton, Ga., and Gainesville, Fla.*

Place	Growing period	Green weight		
		Hairy vetch	Austrian winter peas	Abruzzi rye
		Pounds	*Pounds*	*Pounds*
Tifton [1]	Oct. 15 to Mar. 1	7,519	18,196	7,892
	Oct. 15 to Mar. 15	7,688	18,702	9,520
Gainesville [2]	Oct. 9 to Mar. 8	4,967	5,726	

[1] 4-year average yields, 1926–29. No fertilizer was used with the green-manure crop, but it was used with the preceding corn and cotton crop.

[2] 1 year's results (1929). No fertilizer was used with the green-manure crop or the corn crop preceding.

WHAT CROPS TO PLANT AFTER WINTER LEGUMES

Corn is the principal crop to plant after winter legumes and is likely to remain so, although in the southern part of the Cotton Belt much cotton is planted after them. Corn can be planted within wider limits of time than cotton, and this gives more time within which to turn under the legume. Cotton land is usually prepared early, much of it before the legume is large enough to turn under; but if one learns the art of getting a large early growth of the legume he will have time to prepare and plant part of his cotton crop thereafter.

Where cotton and corn are rotated it is easier to plant the winter legume after the cotton than after the corn, which means that corn will naturally follow the legume. The presence of summer legumes in the corn and the frequent knocking down of the cornstalks across the rows by storms makes it difficult to interplant the winter legume between the rows; therefore the next year's cotton is not preceded by a winter legume. However, where corn is harvested for silage, the conditions are ideal for planting winter legumes, and cotton may follow thereafter.

Other crops, such as sweetpotatoes, sorghum, cowpeas, soybeans, etc., that can be planted in May or June may follow winter legumes.

INCREASED YIELDS OF CORN AND COTTON FROM USE OF GREEN MANURE

Increased yields of corn and cotton have resulted from the use of green-manure crops whenever a good yield of the green-manure crop has been secured and handled in season. The general experience of farmers as well as experimental results indicate the value of this practice. At Tifton, Ga., several legumes were used in comparison with Abruzzi rye and no legume, with the results given in Table 2. Through a 4-year period the average yield for the plots using a winter-legume green manure was consistently higher than on the plots using rye or no legume, the difference in yield being sufficiently great to justify considerable expense on the green-manure crop.

TABLE 2.—*Yields of cotton and corn at Tifton, Ga., following winter green-manure crops, 1926 to 1929, inclusive*[1]

[Yields given are an average for the 4 years]

Green-manure crop used	Acre yield, with complete and incomplete fertilizer			
	Corn		Seed cotton	
	N-P-K[2] 0-10-4[2]	N-P-K 2-10-4[2]	N-P-K 0-9-5[2]	N-P-K 3-9-5[2]
	Bushels	*Bushels*	*Pounds*	*Pounds*
Austrian winter pea	58.3	53.5	1,025	1,001
Hairy vetch	40.7	47.5	749	1,072
Monantha vetch	45.6	45.9	934	1,130
Abruzzi rye	36.3	40.6	829	978
No green manure	37.5	40.9	629	842

[1] Green-manure crops were sown Oct. 1 and turned down Mar. 1 for cotton and Mar. 15 for corn. Fertilizer used, 500 pounds per acre for corn and 1,000 pounds per acre for cotton. No fertilizer was used with the green-manure crop.

[2] Percentages, respectively, of nitrogen (N), phosphorus (P), and potassium (K).

The experiment station at Clemson College, S. C., reports yields for the years 1927 and 1928 comparable to those obtained in Georgia. The average yield of corn per acre for the two years when using a side dressing of sulphate of ammonia of 100 pounds per acre was 13.8 bushels on the rye plots and 27.3 and 25.7 bushels for Austrian winter pea and vetch plots, respectively. In the case of the plots receiving no side dressing, the yield on the rye plot was 5.3 bushels and on the Austrian winter pea and vetch plots 25.3 and 18.5 bushels, respectively. In this experiment the winter crop received 200 pounds of superphosphate and 50 pounds of muriate of potash.

At the experiment station at Auburn, Ala., the increased yield of corn due to plowing down vetch for the years 1925 to 1929, inclusive, was 15.5 bushels per acre when the vetch was turned March 25, 22.2 bushels when turned April 5, and 22.4 bushels when turned April 15. For cotton the increase was 593 pounds of seed cotton per acre when the vetch was turned March 25, 534 pounds when turned April 5, and 460 pounds when turned April 15.

In 1929 and 1930 the writers made a survey of farms using winter legumes in South Carolina, Georgia, and Alabama and obtained estimates from farmers of the increased yields of corn and cotton, due to the use of these legumes, for the years 1925 to 1929, inclusive. The survey covered 353 cases of corn following winter legumes and embraced 4,145 acres of that crop. The average increase in yield of corn for this acreage was 14 bushels per acre. Also, in 147 cases of cotton after winter legumes, covering 1,877 acres, the average increase due to the use of these legumes was 100 pounds of lint cotton per acre.

HOW MANY ACRES OF WINTER LEGUMES PER MULE?

The average farmer in the Southeastern States who has had experience with winter legumes says that 5 acres to the mule is practicable, but he usually falls below this figure in his own practice. It is physically possible, however, to do much better than this. By the use of plenty of seed, early planting, fertilizers, and the legume that makes the best early growth, one may have such a good early growth that he can commence turning a week or 10 days in advance of the usual time. The Alabama Agricultural Experiment Station has already been quoted to the effect that plantings of winter legumes on October 1 have made twice the growth by April 1 of the next year as have those planted November 1; also, the average yield of Austrian winter peas on April 1 from plantings made October 1 for a 5-year period was 9,136 pounds green weight per acre, whereas hairy vetch gave 6,546 pounds for the same period of planting and harvesting.

The season can be further extended by the use of other crops. In late May or the first of June one can plow down a few acres of bur clover or crimson clover after the former is ripe and the latter harvested for seed and can plant to some late crop. If the soil is suited to bur clover that legume will perpetuate itself in a 2-year rotation of late-planted corn one year and cotton the next. Some seed of the bur clover will mature before the crop is turned down, and the "hard" seed will live over in the soil two or more years.

Instead, therefore, of 5 acres to the mule, one can add 3 or 4 more early in the season and 2 or 3 more late in the season, making a total of 10 or 12 acres to the mule in all. Livestock men who keep the legume pastured may have a still larger acreage, and one who has a tractor can handle a larger percentage of his land in winter legumes than one who has not.

There are, of course, large areas in the South where neither crimson nor bur clover do well, but there are possibilities with hop clover and Carolina clover.

IS IT PRACTICABLE TO SAVE SEED OF WINTER LEGUMES IN THE SOUTH?

Wherever crimson clover grows well the seed can be saved by every farmer. Methods of doing this will be found in Farmers' Bulletin 1411.

The production of Austrian winter pea seed and vetch seed is irregular and uncertain, and yields are small even when obtained. Corn ear worms sometimes attack hairy and smooth vetch and defoliate them, but in Rowan County, N. C., seed of smooth vetch has been grown for the market for several years. Farther south there is more danger from the worms. If one chooses to make the attempt, however, he had better watch for the worms every day after pods begin to form, and at the first sign of them he can plow down the crop as a fertilizer. If the worms do not appear he can keep the crop for seed.

Winter peas and the aforementioned vetches are harvested for seed in the South by raking the vines when they are ripe or dead ripe. At this time the vines break off at the ground. They can then be threshed or knocked out with a flail. Shattering is greater with hairy and smooth vetch than with Austrian winter peas and monantha vetch.

RESIDUAL EFFECT OF WINTER LEGUMES

While there are only limited experimental data on the residual effect of winter legumes, there is no doubt that there is such an effect. At the Central Experimental Farm, Ottawa, Canada, a crop of clover grown in 1900 increased the corn crop in 1901, the oats in 1902, and the potatoes, carrots, and sugar beets in 1903. In the latter year the potato increase was 20 bushels per acre, the carrots 11.16 tons per acre, and the sugar beets 13.7 tons per acre.

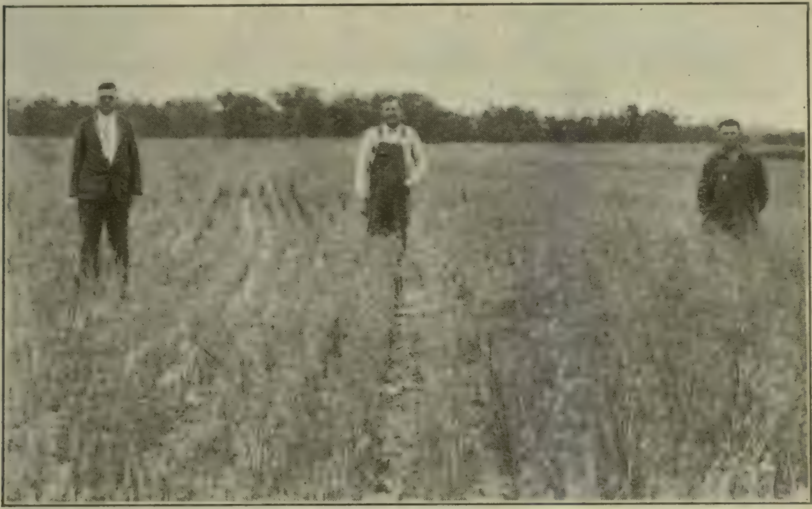

FIGURE 1.—Oats on the farm of D. C. Sims, Lafayette, Ala. At the right, oats in 1930 following cotton which was planted after Austrian winter peas used as a green manure. At the left, oats in 1930 following cotton which was not preceded by any winter legume

At the Alabama Agricultural Experiment Station the vetch turned under in the years 1925, 1926, and 1927 increased the corn yield in 1928 by 9.9 bushels per acre for vetch turned March 25, 19.5 bushels per acre for that turned April 5, and 21.7 bushels for that turned April 15.

If one merely comes out even, financially, on the first crop after winter legumes, he will still find their use advantageous because of their influence on the next year's crop.

Figure 1 shows the effect of Austrian winter peas turned under in the spring of 1929 on the crop of oats in 1930. Cotton occupied all this land in 1929. The winter peas occupied the land on the right but not on the left.

INSECTS AND NEMATODES

In the Cotton Belt but little difficulty with insects has been encountered in growing winter legumes except in cases where the crop has been allowed to stand late in the spring. Serious damage to hairy vetch by the corn ear worm has resulted when the crop has been allowed to stand late in the hope of getting a seed crop. This subject is treated fully in Farmers' Bulletin 1206.

Aphids also may do serious damage to winter green-manure crops that are allowed to continue growth late in the spring. However, the proper season for turning the green-manure crop down for cotton or corn is sufficiently early so that usually but little if any damage is to be expected. In the northern part of the Cotton Belt aphid damage may be expected after April 15, and in the southern part the last of March or early April. When aphids appear in abundance the green-manure crop should be turned under or disked down at once.

Experimental work of the Alabama Agricultural Experiment Station indicates that the damage to the corn crop by the southern corn rootworm is increased when following a green-manure crop. However, little or no damage resulted from plantings made April 15 and later. In latitudes farther north the date of planting to avoid damage by this insect will be somewhat later. This matter is discussed fully in Farmers' Bulletin 950.

The winter legumes commonly used in the Cotton Belt are all subject to attack by nematodes, and under favorable conditions serious damage may result. All other winter legumes used in experimental plantings, so far as observations have been made, are hosts of nematodes. Nematodes are most active during warm weather, and serious damage to the green-manure crop can be avoided by delaying the planting until the last of September or early October, thus bringing the growing season entirely into the cooler part of the year. This has been indicated under the heading Seeding.

CROPS

HAIRY VETCH

(*Vicia villosa* Roth.)

Hairy vetch is one of the oldest and most commonly used green-manure crops of the Cotton Belt. Being one of the most winter hardy of the vetches, it seldom suffers any winter injury. It is usually considered as a winter annual, although it often carries over into the second year as a biennial when sown in the spring. The stems are comparatively weak or viny, ascending only with support. It has a higher minimum or zero growing point than other vetches that are less winter hardy, so that in seasons with a low mean temperature less growth may be expected from this variety than from others with a lower zero growing point. In mild winters, however, or winters having a high mean temperature, hairy vetch may yield as heavily as any less hardy variety. The seed of this variety can not be distinguished from that of smooth vetch, and the two varieties are being sold under the name hairy vetch. In growth, however, the two varieties are very distinct, the hairy vetch having long hairs on the stems and leaves, while the smooth vetch has fewer and less conspicuous hairs. A tufted growth at the ends of the stems of hairy vetch is also characteristic. The flowers of hairy vetch are a little larger than those of smooth vetch and of a less reddish-purple color. (Fig. 2.)

SMOOTH VETCH

(*Vicia villosa* Roth.)

In general, smooth vetch is like hairy vetch and is a variety of the same species but differs in lacking the tufted growth at the ends of the stems and in having fewer hairs or less pubescence on the stems and leaves. The flowers are of a more reddish purple than those of hairy vetch and somewhat smaller. Smooth vetch is winter hardy in the Southern States and as far north as Washington, D. C., but it can not be grown so far north as hairy vetch. It has a lower zero growing point than hairy vetch and for this reason can be expected to make winter growth in seasons and at times too cool for hairy vetch. In experimental work smooth vetch has been one of the best winter legumes under southern conditions. During the last few years seed of this vetch has been imported in considerable quantity under the name hairy vetch. In commercial plantings in the South it has made somewhat better growth than hairy vetch and is to be preferred to that variety.

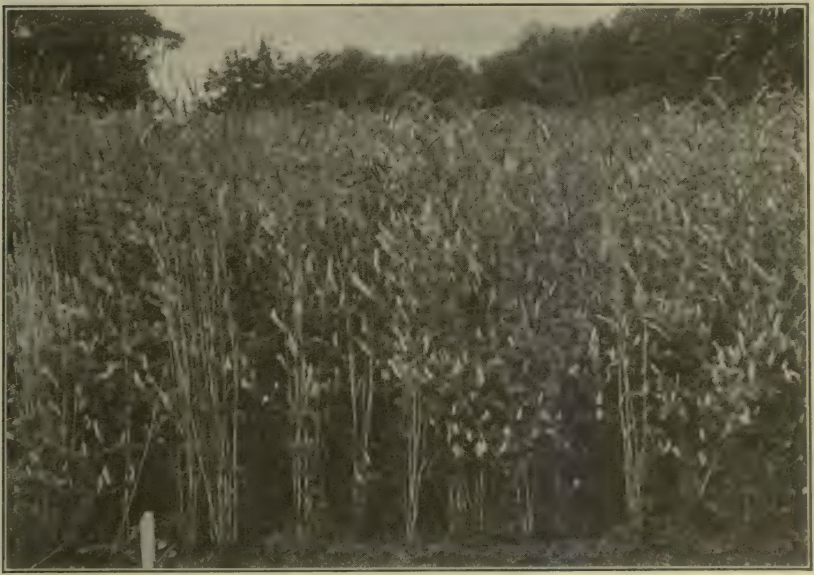

FIGURE 2.—Hairy vetch in mixture with rye, showing the general habit of growth of the vetch

WOOLLYPOD VETCH

(*Vicia dasycarpa* Ten.)

While woollypod vetch has been used in experimental plantings for a good many years and was at one time grown commercially in small quantity, it is not to be found in the trade at the present time, although it is a vetch of proved value for Cotton Belt conditions. The reason for this seems to be a lack of interest in green-manure crops in the South at the time this vetch was commercially available.

In general appearance and in cultural requirements woollypod vetch is very much like smooth vetch. In fact, when growing in the field the two can be very readily mistaken one for the other. The flower of woollypod vetch is a little smaller and a little deeper red than that of smooth vetch. In size and color the flowers of smooth vetch are halfway between those of hairy vetch and woollypod vetch. Unlike smooth vetch, the seed of woollypod vetch can be readily distinguished from that of hairy vetch. It is oval instead of nearly spherical, as in hairy vetch, and has a groove along the dividing line of the seed scar which is not present in hairy or smooth vetch. The seed of woollypod vetch is usually a little larger than the seed of hairy or smooth vetch, but this difference can not always be depended upon. The minimum temperature at which woollypod vetch will make growth is lower than with hairy vetch, and in this respect it is more like smooth vetch. It is a vetch that can be widely used in the Cotton Belt. (Fig. 3.)

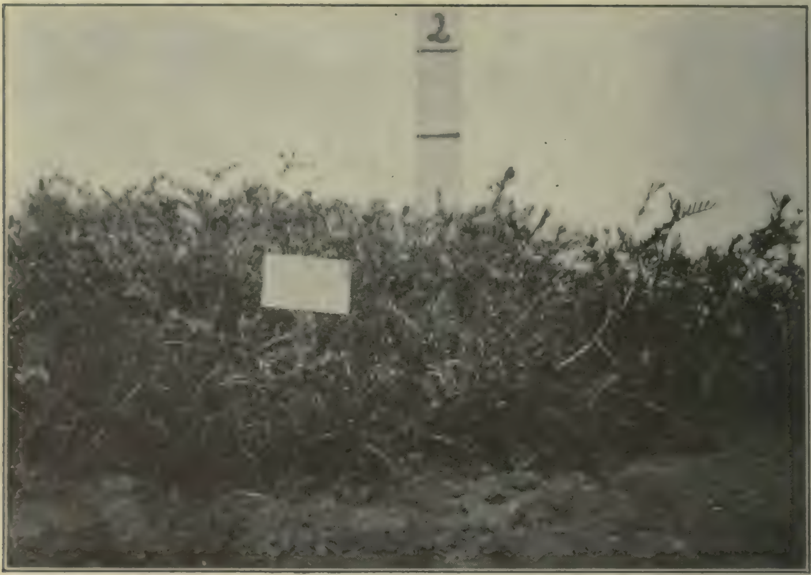

FIGURE 3.—Woollypod vetch in an experimental planting, showing general habit of growth

MONANTHA VETCH

(*Vicia monantha* Desf.)

In general habit of growth monantha vetch is similar to other vetches. It has finer stems and leaves than hairy vetch and is one of the earliest maturing of the vetches. The minimum temperature at which it will make growth is lower than for hairy or smooth vetch or Austrian winter peas, and it is one of the best winter legumes for making growth during winter or periods with a low mean temperature. In point of winter hardiness it is not to be compared with hairy vetch, or Austrian winter peas, or even smooth or woollypod vetch. It can not be safely grown in the northern part of the Cotton Belt and is recommended for use only in Florida, the southern part of Georgia, Alabama, and similar territory.

NARROWLEAF VETCH

(*Vicia angustifolia* Grufberg)

Found as a weed by the roadside and in waste places throughout the Cotton Belt, narrowleaf vetch is like most other vetches and is closely related to common vetch. Its season of maturity is early, and for this reason it ripens seed regularly under southern conditions. The percentage of hard seed in this species is quite high, and this carries over in the soil, giving a volunteer crop from year to year. When planted under field conditions and given ordinary cultural attention it has seldom succeeded. It seems to require some protection, and possibly the accumulated organic matter supplied by weeds or grass, with which it commonly volunteers, is necessary for its growth. It can be recommended for growing in mixture with Bermuda grass or Johnson grass for hay or for volunteering in orchards as a winter crop where a heavy grass growth is allowed to accumulate during the latter part of summer. Narrowleaf vetch will make growth under about the same temperature conditions as bur clover or hairy vetch.

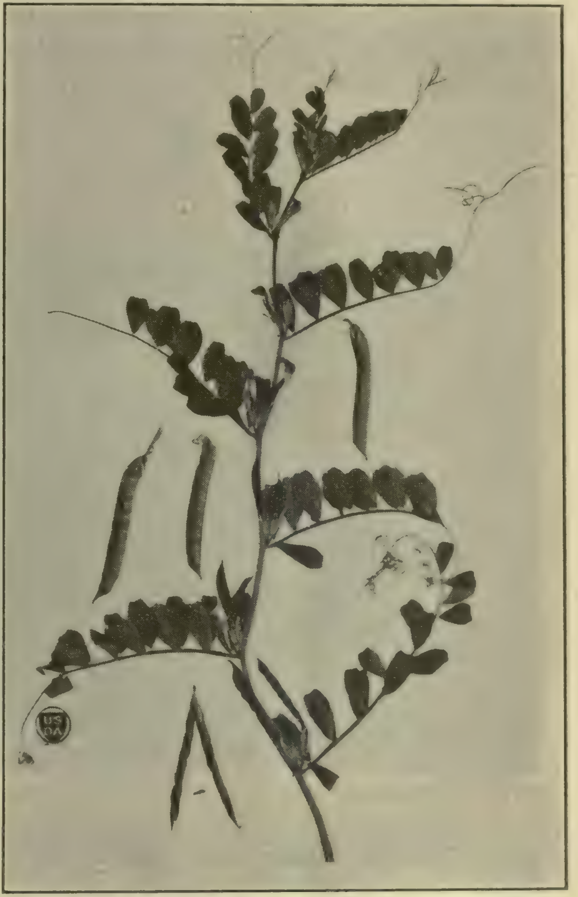

FIGURE 4.—Stem and seed pods of common vetch

COMMON VETCH

(*Vicia sativa* L.)

Common vetch is a semiviny plant having slightly larger leaves and stems than hairy vetch; being less winter hardy than that species, it often winterkills under Cotton Belt conditions. The minimum temperature at which common vetch will make growth is lower than for hairy vetch or Austrian winter peas, and for this reason it is to be preferred where it is winter hardy and is adapted. While this vetch is not used in commercial plantings in the South, it has given good results at a number of places in experimental plantings, and it seems probable that when given proper cultural treatment it can be grown successfully over a considerable area. (Fig. 4.)

HUNGARIAN VETCH

(*Vicia pannonica* Grantz)

Hungarian vetch is a comparatively new species that has become commercially established in western Oregon. Experimental plantings in the Cotton Belt have indicated that it is not so well adapted to sandy lands as other vetches, but on heavy lands it has given good results. It is entirely winter hardy throughout the Cotton Belt and as far north as Washington, D. C. The minimum temperature at which it will make growth is about the same as for bur clover and hairy vetch. Results up to the present time suggest that it may have value for use on the heavier lands of the northern part of the Cotton Belt. (Fig. 5.)

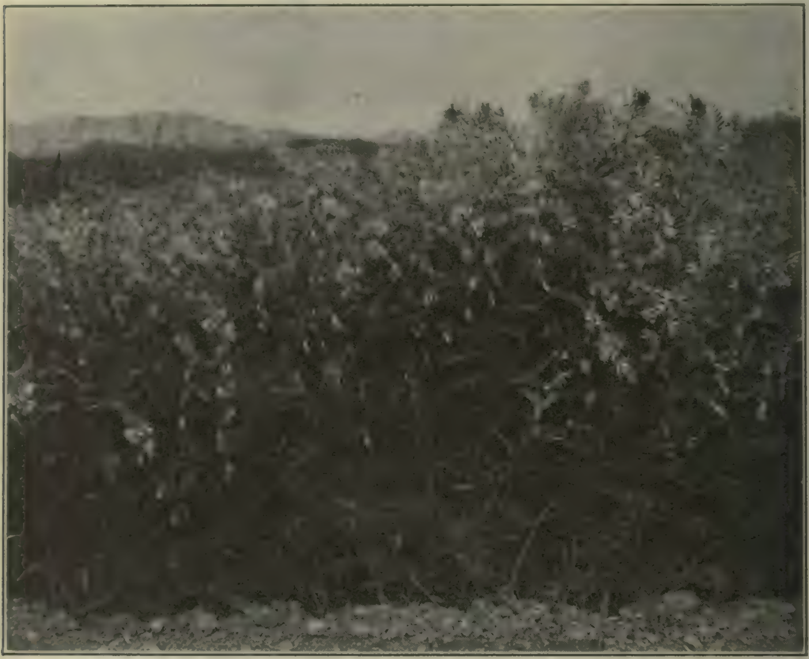

FIGURE 5.—Hungarian vetch in western Oregon, showing its general habit of growth

PURPLE VETCH

(*Vicia atropurpurea* Desf.)

In general appearance purple vetch is similar to hairy vetch, but in winter hardiness it is very different. Being one of the least winter hardy of the vetches, it has usually winterkilled in experimental plantings at stations in the Cotton Belt. The zero growing point or minimum temperature at which it will make growth is lower than for Austrian winter peas, hairy vetch, or smooth vetch, and in this respect purple vetch is desirable, but its lack of winter hardiness precludes its general use in the Cotton Belt.

BITTERVETCH

(*Vicia ervilia* (L.) Willd.)

Bittervetch has been used in the South only in experimental plantings. It is much more upright in growth than most other vetches and in this respect is desirable, but it has made comparatively little growth and has often winterkilled, indicating that its use under Cotton Belt conditions at best will be limited.

BARD VETCH

(*Vicia calcarata* Desf.)

The general habit of growth of bard vetch is similar to that of hairy and common vetch. In experimental plantings at a number of southern stations it has made but little growth, and it does not promise to be of much value under Cotton Belt conditions.

HORSE BEAN

(*Vicia faba* L.)

While the horse bean is related to the vetches, it is quite different from most of them in general appearance. It is a coarse upright-growing plant having large, broad leaflets. There are a large number of varieties, but all require more or less the same general climatic and cultural conditions. The minimum temperature at which the horse bean will make growth is comparatively low, this plant being comparable to purple and monantha vetch in this respect. It usually produces a succulent growth in late fall or during warmer spells of the winter and is subsequently frozen and killed. Experience with the horse bean in the Cotton Belt has not indicated that it is to be recommended for use as a winter green manure.

TANGIER PEA

(*Lathyrus tingitanus* L.)

The general habit of growth of the Tangier pea is similar to that of the common garden sweet pea. In winter hardiness it is similar to monantha vetch, being much less hardy than hairy vetch or Austrain winter peas. The minimum temperature at which it will make growth is about the same as, or slightly lower than hairy vetch. A very rapidly growing plant at moderate temperatures, it gives a heavy yield of green manure. Experimental plantings suggest that it will make good growth in most seasons in the southern part of the Cotton Belt, but it has not been found superior to monantha vetch and Austrian winter peas. As the seed habits of Tangier peas are poor and the cost of seed correspondingly high, its use no doubt will be very limited.

AUSTRIAN WINTER PEA

(*Pisum arvense* L.)

The variety of pea introduced to the trade several years ago under the name Austrian winter seems to be identical with the gray winter variety. It is one of the most winter hardy of the pea varieties and makes good growth under Cotton Belt conditions. The plants are viny, ascending only with support. It has a low minimum growing point and in this respect is about like smooth vetch and woollypod vetch. It makes a good growth under southern winter conditions and is one of the best winter legumes for general use. It has a greater acreage planting than any other winter legume with the exception of hairy vetch. Its more general use has been limited by an inadequate seed supply. This situation will soon be relieved, as the seed can be grown easily and is comparatively cheap. (Fig. 6.)

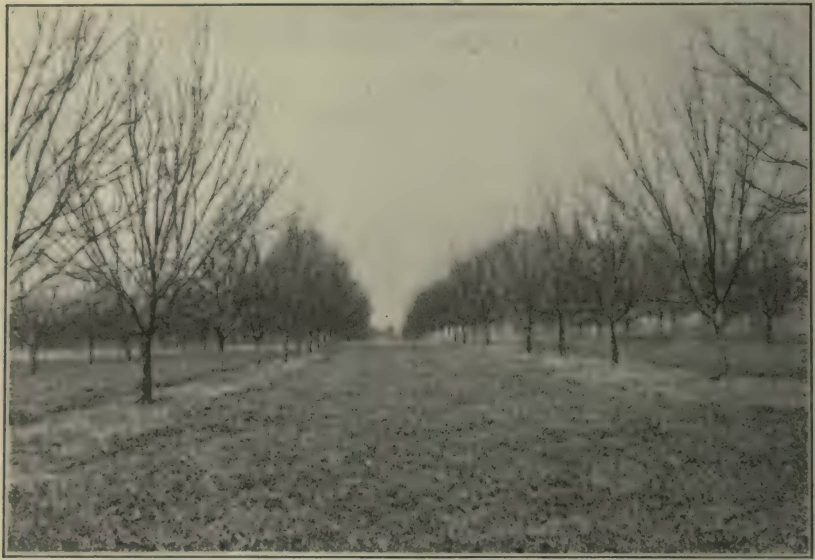

FIGURE 6.—A good growth of Austrian winter peas in a pecan grove in southern Georgia

BUR CLOVER

(*Medicago* spp.)

Two species of bur clover are grown in the Cotton Belt—southern bur clover (*Medicago arabica* (L.) All.) and Tifton bur clover (*M. rigidula* (L.) Desr.). The Tifton bur clover is a recent introduction that has been grown and distributed from the Georgia Coastal Plain Experiment Station at Tifton, Ga., from which place it takes its name. While it makes a decumbent growth and in general is like the southern bur clover, it differs in having leaves of a darker green color and lacks the dark-purple spot in the middle of each leaflet characteristic of that species. It also is more winter hardy than the southern bur clover. The California bur clover (*M. hispida* Gaertn.) is occasionally sown in the Cotton Belt States, but usually without success, as it is less winter hardy than the Tifton or southern bur clover and is often damaged severely by cold weather.

The minimum temperature at which the bur clovers will make growth is somewhat higher than that of smooth vetch or woollypod vetch, but about the same as for hairy vetch.

CRIMSON CLOVER

(*Trifolium incarnatum* L.)

Crimson clover is recognized as a good winter legume, but it is sometimes difficult to get a good stand. This uncertainty has prevented a much wider use of the crop for green-manuring purposes. It is best adapted to the more northern part of the Cotton Belt and is used most extensively from northern Georgia and northern Alabama northward to New Jersey. It will not make growth at as low a temperature as Austrian winter peas and woollypod and smooth vetch, but at slightly higher temperatures it makes rapid growth. (Fig. 7.)

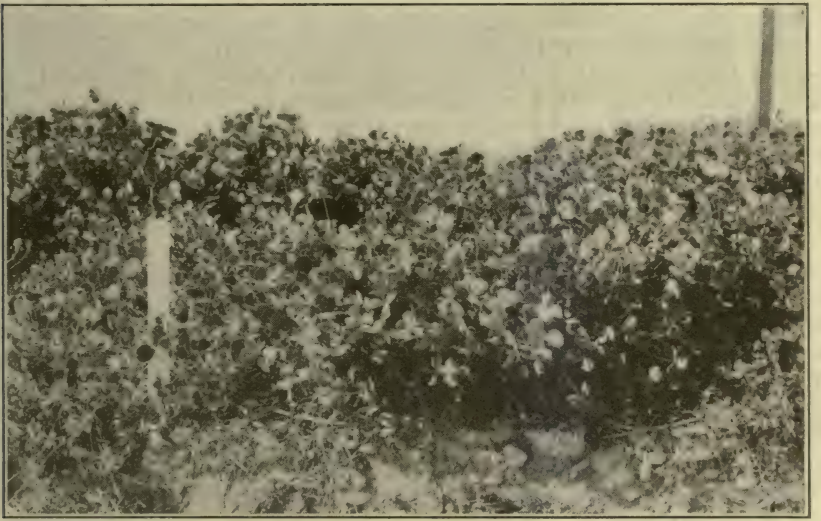

FIGURE 7.—A good growth of crimson clover about ready to turn down for green manure

SOUR CLOVER

(*Melilotus indica* (L.) All.)

Sour clover is an upright-growing winter annual that has been used extensively for green manure in the southwestern United States. Its use in the Cotton Belt has been limited to the lower Mississippi Delta area and the black lands of Mississippi and Alabama, and it is not recommended for general use outside of this territory. It does not seem to be well adapted to other lands of the South and on such succeeds only with heavy applications of lime and superphosphate.

The minimum temperature at which sour clover will make growth is higher than for Austrian winter peas, smooth vetch, and woollypod vetch, and it has about the same temperature-growth requirements as bur clover. The seed of sour clover usually has been cheap, and as only a small quantity is needed for seeding, it is a crop that can be grown with but little expense.

FENUGREEK

(*Trigonella foenumgraecum* L.)

While fenugreek has been grown for a winter green-manure crop in California, it has never been grown successfully in the Southern States. In experimental plantings it has made but little growth and seems to be unsuited to general southern conditions. Further experimental work may demonstrate limited areas to which it may be suited or indicate cultural practices that may make for success. The minimum temperature at which fenugreek will make growth is about the same as for bur clover and sour clover, and it is much like these crops in winter hardiness.

SERRADELLA

(*Ornithopus sativus* Brot.)

Serradella is a semivining plant more or less like the vetches in general habit of growth. It is used in Germany on sandy lands for soil improvement, but it has never been grown commercially in the United States. In experimental plantings in the South it has generally failed to make good growth except in a few cases where the soil was well supplied with accumulated organic matter.

LUPINE

(*Lupinus* spp.)

While lupines have been used in Germany for soil improvement, they have never been grown commercially in the United States. In Germany they have proved especially valuable for green manure on sandy lands and have been grown extensively for this purpose. The white lupine (*Lupinus albus* L.), yellow lupine (*L. luteus* L.), and blue lupine (*L. hirsutus* L.) are the species most used. These are all upright-growing plants well suited for green manuring. In experimental plantings in the United States poor stands have usually resulted; however, the few seeds that germinate often make very good growth.

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U. S. GOVERNMENT PRINTING OFFICE: 1931

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1664

CHRISTMAS TREES AS A CASH CROP FOR THE FARM

CHRISTMAS TREES as a side-line crop may prove profitable in many localities, both as a source of cash return and as a means of utilizing waste land on the farm. If desired, such production may readily be combined with forest planting for timber production.

Remoteness from large natural supplies of Christmas trees and nearness to good markets are essential to the success of the venture.

The spruces, true firs, Douglas fir, deodar, and eastern red cedar are suitable for Christmas-tree plantations.

Where a market exists for table trees, first returns are possible within 1 to 3 years after the plantation is established. The main crop, with cultivation, matures ordinarily about 7 or 8 years after planting.

The Christmas-tree crop is not perishable and can be held over from one year to the next, if no cutting is done until orders are received.

Washington, D. C. **Issued May, 1931**

CHRISTMAS TREES AS A CASH CROP FOR THE FARM

By F. H. EYRE, *Silviculturist, Branch of Research, Forest Service*

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CHRISTMAS TREES A PROFITABLE SIDE LINE ON THE FARM

THE GROWING of Christmas trees as a crop affords a profitable side line for the farmer in some sections of the United States. The crop, in addition to being an added source of revenue, is sold at a time of year when extra income is particularly acceptable.

A market for Christmas trees exists in every town and city, and with urban growth a corresponding increase in the demand for trees may be expected. At present most of this demand, and especially that in the cities, is supplied by natural-grown trees harvested from the extensive timberlands of the North and West. These trees, cut weeks and even months before Christmas, are bundled tightly together and shipped long distances to market, with consequent damage to many trees. As the trade is largely unorganized and speculative, markets during some years are glutted and in others are insufficiently supplied. This kind of marketing entails much waste.

A shapely home-grown tree is far superior to one shipped in from a distance. If cut and delivered promptly a short time before Christmas it will retain its fragrance and foliage throughout the holiday season, unlike the shipped-in tree which is apt to shed its needles as soon as it is brought into a warm room.

A few farmers have already recognized the superiority of home-grown trees and the opportunities for selling them. As a result, some trees are now produced on farms on a crop basis, principally for local sale. The indications are that this practice could be extended in many localities.

The problem of utilizing idle farm land can be solved in part by growing Christmas trees. (Fig. 1.) On many farms there are fields exhausted by years of cropping, land which is eroding or washing, odd corners of tillable land not handily situated for cultivating in regular field crops, or excess pasture land. In proper locations small areas of such lands, if planted to Christmas trees before they are reclaimed by brush and briers, can be made to yield a return instead of becoming a liability.

The growing of Christmas trees may be combined with forest planting for timber production on larger areas. Christmas trees can either be interplanted with those desired in the final crop of timber or, where the species is suitable, can be planted more densely than would otherwise be advisable and thinned when large enough to sell.

The production of Christmas trees on the farm is less difficult than the growing of many garden and truck crops. Considerable care is required in starting the plantation but, once established, very little time need be given to make it a success. Cultivation can be carried on at odd times without interfering with other farm work, and harvesting and marketing take place when most other farm business is at a standstill.

F-68110

FIGURE 1.—Idle land can be used for growing Christmas trees

WHERE THE FARM SHOULD BE LOCATED[1]

Though it is true that a market for Christmas trees exists in every town and city, the distance of these markets from the farm, the possibility of strong competition from wild or natural-grown trees, and the presence of similar plantations should be carefully considered before a plantation is started. A farm located within wagon or truck hauling distance from a large town or city and remote from an extensive supply of wild trees would appear to be well situated so far as a market is concerned. The principal sources of wild trees of the species most in demand for Christmas display, viz., the spruces, balsam fir, and Douglas fir, are northern New England and New York, the northern part of the Lake States (Minnesota, Wisconsin, and Michigan), Canada, and the Pacific Northwest. Other species, such as northern white pine, the southern pines, hemlock, red cedar, and redwood, are used locally to a variable extent, depending upon accessibility and abundance. Many desirable locations for producing Christmas trees are to be found in the Eastern and Central States.

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[1] Sometimes it becomes necessary to establish quarantines against the spread of insect pests or fungous diseases and to limit interstate shipment of trees and nursery stock. As these quarantines frequently follow State boundaries, it is desirable to locate the plantation in the State where the markets for the product are found. The Plant Quarantine and Control Administration, U. S. Department of Agriculture, Washington, D. C., can furnish up-to-date quarantine information at any time.

KIND OF TREES TO PLANT

The kind of tree to plant is one that is attractive for Christmas use, is suited to the locality where it is to be grown, and is capable of making good growth. The ideal Christmas tree is symmetrical, with a dense, compact crown, possesses sufficient stiffness of branches to hold up decorations, and is fragrant and retentive of its foliage when brought into a warm room. The spruces and true firs combine many of these qualities. Other good trees are the Douglas fir, deodar, and eastern red cedar.

The following are characteristics of some of the species suitable for Christmas trees:

Norway spruce (*Picea excelsa*) (fig. 2, A), introduced into North America many years ago from Europe, has been grown in many parts of the United States as an ornamental tree. It is easy to propagate, makes rapid growth, and has a wide range of adaptability. Because of these qualities and of the fact that planting stock may usually be purchased more cheaply than that of other suitable species, Norway spruce has much to recommend it for Christmas-tree planting, even though its color and form are somewhat inferior to those of slower-growing trees.

Blue spruce (*Picea pungens*),[2] which occurs naturally in the Rocky Mountains, is a beautiful tree with a particularly dense, well-formed crown. (Fig. 2, B.) It is not difficult to cultivate but is slower growing than the Norway spruce. Its striking blue color and dense foliage make it very popular and especially desirable for sale as a living Christmas tree.

White spruce (*Picea glauca*) (fig. 2, C), which grows naturally in the extreme northern part of the United States, is well adapted to planting where the climate is severe. It grows less rapidly than Norway spruce but is frequently superior in color and shape.

White fir (*Abies concolor*), a tree of the western United States, has been widely planted as an ornamental throughout the East and is suitable for Christmas-tree planting. (Fig. 3, A.) For eastern planting, stock from Rocky Mountain seed should be selected rather than that from the Pacific coast, to insure hardiness.

Balsam fir (*Abies balsamea*) is a beautiful tree as it occurs in the north woods and is widely marketed as a natural-grown tree. It is, however, not so successfully grown outside its natural range as

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[2] The ordinary blue spruce grown from seed varies a great deal in color and should not be confused with the Koster blue spruce. This variety, which always has a light-bluish cast, is usually propagated by grafting.

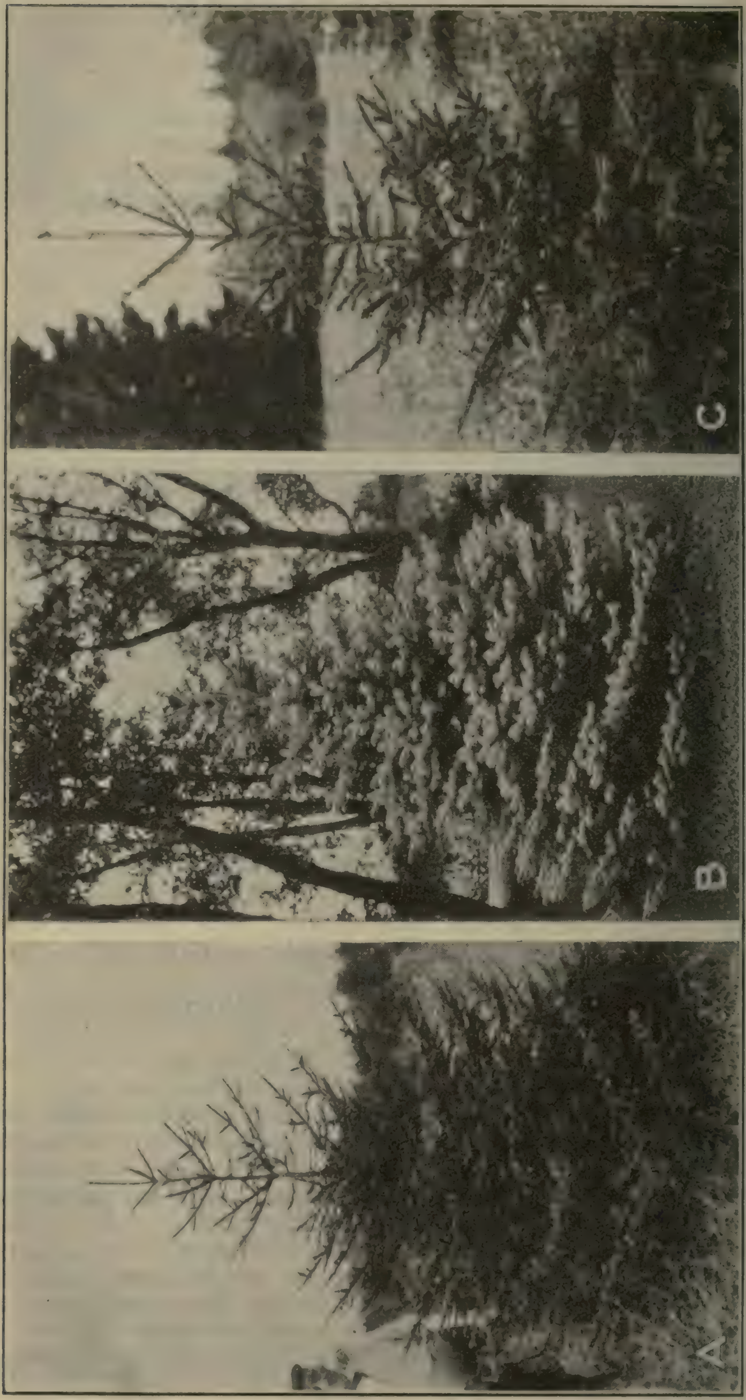

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FIGURE 2.—Desirable species for Christmas-tree planting: A, Norway spruce; B, blue spruce; C, white spruce

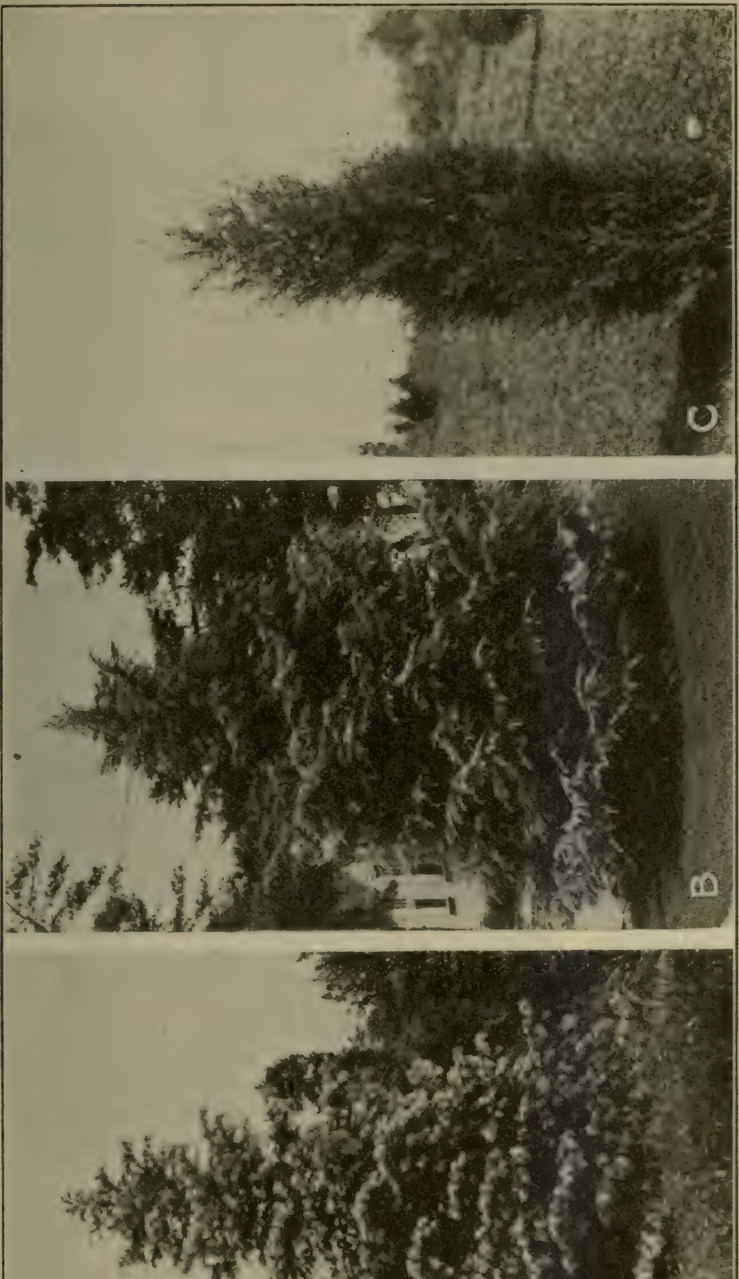

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FIGURE 3.—Desirable species for Christmas-tree planting: A, White fir; B, deodar; C, eastern red cedar

are some of the other firs. Because of this fact and the marked tendency of its lower limbs to lose their foliage, especially when crowded by rank-growing weeds, it is not particularly desirable for Christmas-tree planting.

Deodar (*Cedrus deodara*) (fig. 3, B), a tree brought to the United States from Asia, has been extensively and successfully planted. It is very graceful in appearance and makes a good Christmas tree. It is particularly well adapted for growing on the Pacific coast and in the warmer parts of the East and Middle West.

Douglas fir (*Pseudotsuga taxifolia*) (fig. 4), which is distributed widely in nature throughout the western mountains, should be classed with the species suitable for Christmas-tree planting. For eastern planting, stock grown from Rocky Mountain seed instead of that from the Pacific coast should be insisted upon to insure hardiness. Moreover, the Rocky Mountain form of Douglas fir is more disease resistant than the Pacific coast form when planted in the East. This tree is somewhat slower in growth rate than Norway spruce but is superior in form and color.

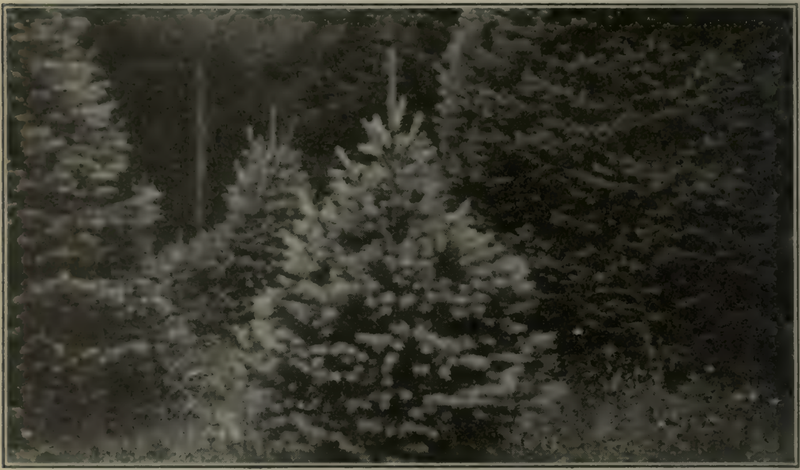
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FIGURE 4.—Douglas fir is suitable for Christmas-tree planting

Eastern red cedar (*Juniperus virginiana*) (fig. 3, C), whose natural range extends from Canada to the Gulf and from the Atlantic to the Great Plains, is suitable for Christmas-tree planting but is a slow grower except in the warmer parts of the country.[3] It is better adapted to the southern part of the Plains area than some of the other species mentioned.

ESTABLISHING THE PLANTATION

SOURCE OF PLANTING STOCK

Stock may be obtained from reputable nurserymen or in exceptional cases may be grown on the farm. Local forestry agencies

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[3] The eastern red cedar is the alternate host for the apple rust. Therefore it should not be planted in sections where apple growing is an important industry.

(see list on p. 15) are best able to furnish information as to the cheapest and best places to buy planting stock or seed and can give advice regarding the species best adapted to the locality in question. It is recommended that before establishing the plantation the nearest forestry agency be consulted as to the feasibility of the undertaking.

Although it is possible to grow conifer planting stock on the farm from seed, it is not an easy undertaking. Conifer seedlings are very tender, need considerable care, and are susceptible to nursery diseases. Therefore, special precautions must be followed in order to insure success. For individuals interested in growing their own stock from seed, detailed information may be found in Farmers' Bulletin No. 1453, Growing and Planting Coniferous Seedlings on the Farm.[4]

KIND OF STOCK TO USE

It is advisable in establishing the plantation to begin with good, strong 4-year-old transplants—stock that has been in the seed bed 1 or 2 years and in the transplant bed 2 or 3 years—in order to hasten the date when a cash return may be realized. Two-year-old seedlings, however, may be obtained at a much lower price and, after growing in transplant rows for 2 years, may be set out in the plantation. The seedlings should be placed 3 or 4 inches apart in some convenient place for tending, such as the vegetable garden. Occasional watering and cultivation make for the development of sturdy, well-rooted transplants. This method is especially desirable for growing replacement stock before harvesting begins.

SELECTION OF SITE

Almost any soil of good texture will grow conifers, but the greatest success is obtained where the extremes of coarse sands and heavy clays are avoided. Coarse sands during drought periods dry out excessively, and heavy clays heave with frost action and sometimes uproot many plants the first season after planting. Swampy soils are also undesirable. If the Christmas-tree project is to be combined with a general planting program for the farm it is well to keep in mind that, as a rule, spruces and firs require better quality soils than do the pines, particularly the hard pines such as Norway, pitch, or shortleaf.

The choice of rough land or land that can be cultivated depends largely on whether the plantation is to be used for Christmas trees exclusively or whether a timber crop is the ultimate aim. In the first case tillable land is to be preferred; in the latter it makes little difference because the Christmas trees are merely fillers which are to be removed when of merchantable size. Steep slopes subject to erosion should not be cultivated when used for Christmas-tree plantations. On moderate slopes cultivation should be along the contour and not up and down the hill, in order to keep soil erosion to the minimum.

Other things being equal, if the plantation is within sight of the house it is safer from theft than if on a remote part of the farm.

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[4] Obtainable free from U. S. Department of Agriculture, Washington, D. C.

PREPARATION OF SITE

If cultivation of the plantation is contemplated, it always pays to prepare the land for planting. Planting costs are lower, and weeds are kept down more easily the first year if the land has been fairly well prepared. Fall plowing followed by disk harrowing in the spring is ordinarily sufficient. In the Plains region or elsewhere where rainfall is scant, summer fallow is recommended in order that sufficient moisture may be stored in the soil to insure survival of the young trees. Where no cultivation is contemplated, either because of steep slopes or because the raising of Christmas trees is merely incidental to a reforestation project, preparation of the site before planting is not necessary.

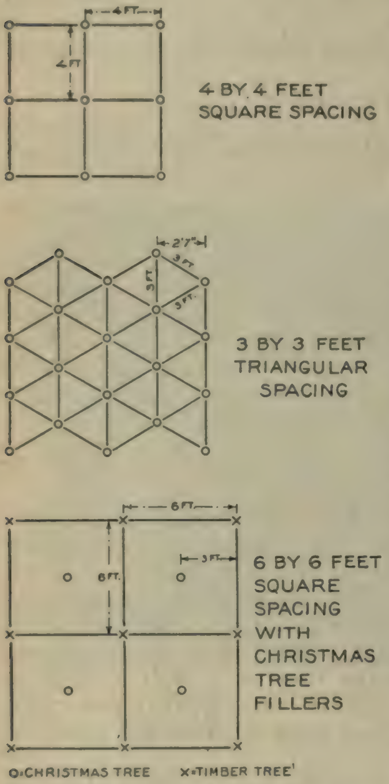
4 FT.
4 FT.
4 BY 4 FEET SQUARE SPACING
2'7"
3 FT.
3 FT.
3 BY 3 FEET TRIANGULAR SPACING
6 FT.
3 FT.
6 FT.
6 BY 6 FEET SQUARE SPACING WITH CHRISTMAS TREE FILLERS
O=CHRISTMAS TREE
X=TIMBER TREE

FIGURE 5.—Possible spacing arrangement

SPACING

Proper spacing is essential to the development of well-formed trees. The spacing to use depends largely on the amount of land available and intentions regarding cultivation. If plenty of land is to be had, a 4 by 4 foot square spacing is recommended because it provides ample room for cultivation and good development of the trees. This will allow the planting of about 2,700 trees to the acre.

A triangular 3 by 3 foot spacing is well adapted to a timber plantation where thinnings for Christmas trees are contemplated. Such spacing allows 5,600 trees to be planted to the acre. Two-thirds to three-fourths of them may be taken out later as Christmas-tree thinnings, and still a sufficient number will be left to grow into timber. If care be taken in thinning to leave the remaining trees evenly spaced, the growth rate of the timber plantation will be speeded up greatly and farm timbers produced in a much shorter time than would otherwise be the case.

Where pines or some other species not particularly desirable for Christmas trees are to be planted for timber production, spruces or firs may be grown as fillers. Square spacings 6 by 6 feet (1,210 to the acre) or 8 by 8 feet (681 to the acre) are commonly used for timber plantations. By filling in between the rows an equal number of Christmas trees can be grown on the same area. When of sufficient size to sell these may be removed, leaving the timber plantation correctly spaced for proper development. Figure 5 illustrates spacing arrangements.

PLANTING

Spring is usually a better time to plant than fall, although fall planting may be successfully undertaken when favorable moisture conditions prevail. Spring planting should be done after the frost is entirely out of the ground but before growth starts; fall planting, after rains have thoroughly moistened the soil but before the ground is frozen. When it is not possible to set out the plants as soon as they are received from the nursery, they may be stored a day or two if kept in a cool, damp place with the roots well packed in wet moss or similar material. When it is necessary to hold stock longer than this it should be "heeled-in" in a shady place; that is, the roots should be thoroughly packed with well-watered earth in a shallow trench.

It is also essential that the roots be kept moist while planting is taking place. Stock which has been dug and is awaiting planting should be covered with wet burlap or kept with the roots in water. Two men can work together to advantage in the planting operation, one to make the hole or slit with a mattock, spade, or dibble, and the other to carry the stock and set the plant. It is a good plan to carry the stock in a pail about one-fourth full of water. A hole should be dug with a mattock or a slit made with a dibble or spade, the roots carefully spread out with the fingers, fine dirt drawn around them, then coarser soil put on top. After setting the young tree, the soil around it should be thoroughly tamped with the mattock or foot. Care should be taken with spruce to set it no deeper than it grew in the nursery. Figures 6 and 7 illustrate the planting operation.

CULTIVATION AND CARE

As trees respond to cultivation and care much as annual farm crops do, it always pays to cultivate where slopes are not too steep or the soil too rocky. (Fig. 8.) Cultivated trees grow more quickly and also are more vigorous and losses due to drought and other causes are less among them. In the more arid sections where there is a deficiency of soil moisture, cultivation is especially needed. An experiment conducted at Michigan State College of Agriculture and Applied Science showed cultivated Norway spruce to be 59 per cent taller at the end of four years than trees that were not cultivated.[5] Weeds, which in dense growths are apt to shade out and cause the loss of foliage on the lower branches and even to kill weaker trees, are effectively kept down by cultivation.

Cultivation three or four times each summer for the first two years is usually sufficient. The third year cultivation will probably pay if trees are spaced as much as 4 feet apart, but where spacing is closer it may cause injury to the roots. Thereafter, the cutting of large weeds and briers which appear to be choking the trees may be of benefit. Plantations may be cultivated at odd times when other farm work is not pressing.

Fertilization is not necessary if the soil is fairly good, but it will increase the growth of the plantation. It should, however, be dis-

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[5] Michigan Agricultural Experiment Station Special Bulletin 145, Christmas-Tree Plantations.

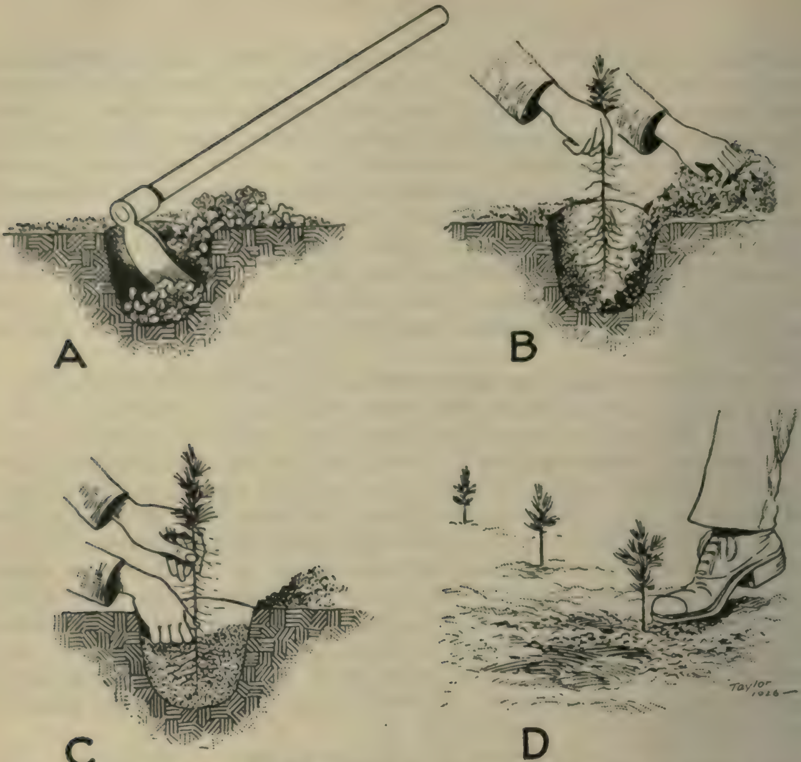

Figure 6.—Planting with the mattock: A, Dig hole large enough to spread the roots; B, partly fill the hole and pack the soil; C, pack the soil twice before filling the hole; D, firm the soil with sole of shoe and scrape loose soil or litter over the surface

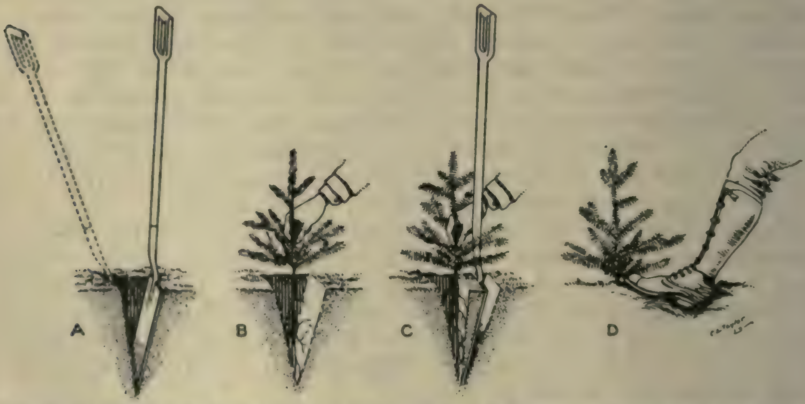

Figure 7.—Slit method of planting: A, Open slit with spade; B, insert tree and hold with hand until set; C, close slit by thrust with spade; D, close entire hole by thrust of heel

continued if the result is to force height growth at the expense of compactness of crown, thus causing the development of spindly trees. A tendency of trees to turn yellow ordinarily may be corrected by application of barnyard manure or a commercial fertilizer rich in nitrogen.

PROTECTION

Plantations need protection from fire, livestock, and insects and fungous diseases.

Fire, the arch enemy of the forest, is particularly disastrous to young trees. Dry grass carries fire readily and burns with sufficient heat to wipe out a stand of Christmas trees. Cultivation reduces the fire hazard materially by turning up the mineral soil and keeping down the grass and weeds. Additional protection can be given a plantation by plowing 8 to 12 furrows around it. This line should be kept bare of vegetation by cultivation in order to be most effective. This simple precaution is especially important in plantations after cultivation has been discontinued and in areas where Christmas trees are being grown in conjunction with timber.

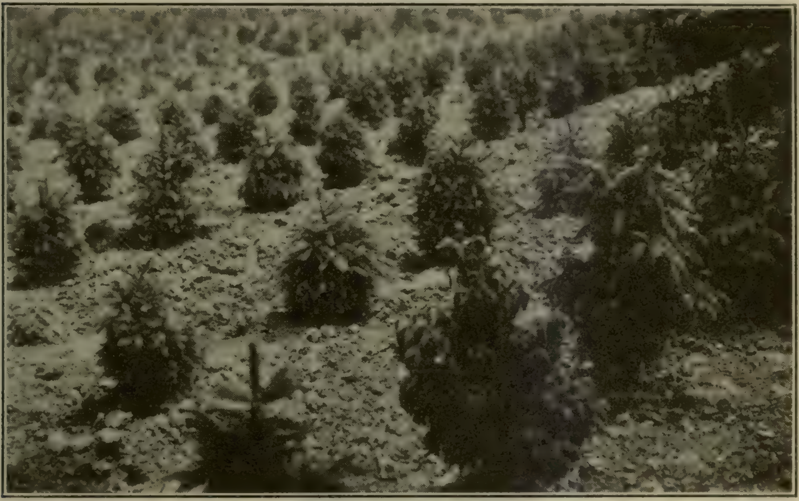

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FIGURE 8.—It pays to cultivate the first two or three years where the slope is not too steep or the soil too rocky

Though under certain conditions some classes of livestock may assist in keeping down the grass, animals are very apt to damage a plantation by trampling and browsing. For this reason it is desirable to keep them out. A fence that excludes livestock also reduces the danger of theft.

Although the species recommended for planting are reasonably free from pests, crops of Christmas trees, like other farm crops, run the risk of attack by insects and diseases. In case of attack by either, control measures in small cultivated plantations are distinctly feasible. As soon as any evidence of insect damage is noted, specimens of the insects and their work should be sent to the Office of Forest Insects, Bureau of Entomology, Department of Agriculture, Washington, D. C., for identification. Recommendations for control of the insects will be made. The Office of Forest Pathology, Bureau of Plant Industry, Department of Agriculture, stands ready to perform a similar service when any disease enters the plantation.

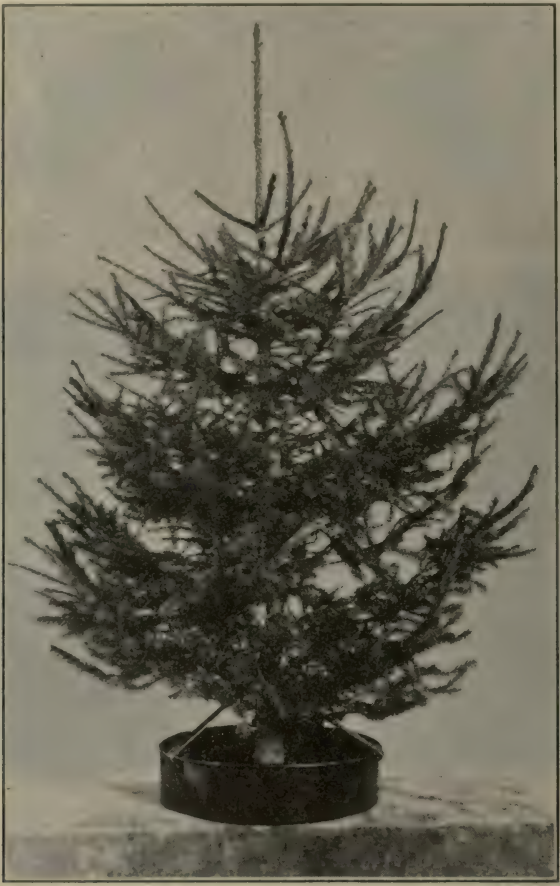

FIGURE 9.—Table trees are becoming more and more in demand. (Photograph by courtesy of the American Forestry Association)

In dealing with either insects or diseases, prompt action is essential in order to stamp out the pest before extensive damage occurs.

TIME REQUIRED TO GROW A CROP

Fortunately, there is no standard size to which Christmas trees must be grown before they become merchantable. With the increase in the number of apartments in the cities, there has developed a market for table trees from 1 to 3 feet tall or even smaller. (Fig. 9.) Trees begin to reach this size within 1 to 3 years after the plantation is established, provided 4-year-old stock was planted and cultivation practiced.

Although table trees are increasingly in demand, trees 4 to 7 feet tall are the sizes most readily sold. Under fairly favorable conditions, some Norway spruce trees in a plantation of that species reach this size 4 to 6 years after the plantation is started, provided good-sized stock, such as that recommended, was used and cultivation was practiced. The main crop should mature in 7 or 8 years. The other species may require 2 or 3 years longer. There are certain to be variations in growth between plantations, because of differences in soil, species, and climate. Even within a given plantation growth is apt to vary between wide limits.

This point is well illustrated in Table 1. The smallest tree was little more than 6 inches tall at the end of 4 years, whereas the largest was nearly 5 feet in height. The average tree was computed to be 2.1 feet in height. A large percentage of the trees in this plantation are already of suitable size to sell as living Christmas trees or small cut trees for table display. In 2 or 3 more years a goodly proportion of the stand should be large enough to sell for general Christmas use. Figure 10 illustrates the plantation for which the figures are given.

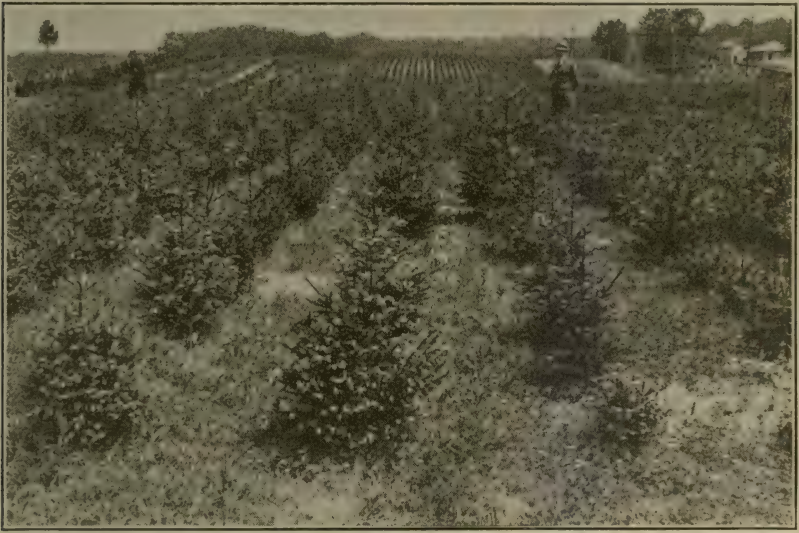

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FIGURE 10.—Within a given plantation growth is apt to vary between wide limits. Some trees are already merchantable in this 4-year-old plantation

TABLE 1.—*Height of trees in Christmas-tree plantation*[1] *of Norway spruce, four years after establishment on poor clay loam soil, Fairfax County, Va.*

Height class (feet)	Trees in height class (number)	Per cent	Height class (feet)	Trees in height class (number)	Per cent
0.0–0.5	0	0	3.1–3.5	6	2.6
0.6–1.0	5	2.1	3.6–4.0	1	.4
1.1–1.5	35	14.8	4.1–4.5	0	0
1.6–2.0	82	34.8	4.6–5.0	1	.4
2.1–2.5	72	30.5			
2.6–3.0	34	14.4	Total	236	100.0

[1] 4-year-old transplants were planted and cultivation was practiced for 2 years after establishment.

Table 2 gives growth figures for a cultivated plantation of Norway spruce in southern Michigan. In this plantation the best trees reached salable size within 3 or 4 years after planting and the average trees within 4 to 6 years. Owing to somewhat slower growth rate in plantations where cultivation is not practiced, several years should be added to these periods when estimating the time required to grow a crop without cultivation.

TABLE 2.—*Height of trees in cultivated plantation of Norway spruce in southern Michigan* [1]

Item	Average of 10 largest trees	Average of 10 smallest trees	Average of 320 trees
	Feet	*Feet*	*Feet*
Height planting stock	1.8	1.4	1.4
First year	2.7	1.7	2.1
Second year	4.0	2.3	3.0
Third year	5.7	2.9	4.1
Fourth year	7.2	3.2	4.9
Fifth year	8.4	3.4	5.5
Sixth year	9.5	3.6	6.0

[1] Michigan Agricultural Experiment Station Special Bulletin 78, Christmas-Tree Plantations

HARVESTING AND MARKETING

If the production of Christmas trees as a crop is to be profitable most careful attention should be given to marketing. The best prices are obtained for freshly cut trees of good form, and these have the best chance in competition with carload shipments of natural-grown trees with which the markets are occasionally flooded. Accordingly, special emphasis should be given prompt delivery when arrangements are made for selling the crop.

Various markets are available. A man who has a local trade for farm produce can readily sell a small number of trees. More can be sold to stores and general-produce markets. Many people like to cut their own trees, so that with a little advertising a number of trees can be sold direct from the plantation. Unlike most other farm crops, Christmas trees not harvested in any one year can be held over to the next without loss. It may even be advisable to hold a few of the larger trees in the plantation until they reach a height of 8 to 15 feet to sell to churches, schools, lodges, and similar organizations. Such trees bring especially good prices. The few poorly formed trees that occur can be utilized by cutting boughs from them to be sold for special decorative purposes. Any surplus not utilized for Christmas trees can be left to grow into valuable timber.

In harvesting the trees, it should be borne in mind that appearance on the market is of importance. The butts of the trees should be cut off squarely so that subsequent trimming by the purchaser is unnecessary. Table trees, other than the living ones, may be easily and neatly cut with a pair of long-handled pruning shears. A handsaw is the most efficient tool for harvesting the larger trees.

Trees which are to be marketed as living trees can be displayed in wooden boxes or tin cans or pots about the size of a 5 or 10 pound lard pail, depending on the size of the tree. If the box or can be painted an attractive color, it helps to sell the product. Living trees should be dug with care in order to preserve a good root system and should be packed in wet sphagnum moss or in soil if weight in transporting the trees is not too much of a factor. A light wooden cover for the receptacle will provide stability for the tree and will reduce evaporation of moisture. Frequent watering of living trees is absolutely essential to keep them alive until such time as they are planted in the ground.

REPLACEMENTS

In order to maintain the business on a permanent basis, gaps which appear here and there throughout Christmas-tree plantations as harvesting takes place may be filled by planting new stock next to the stumps of the old trees. When most of the old stand has thus been replaced, it may be possible to resume cultivation, provided the grass and weeds have not become too rank to make this feasible.

As a substitute measure for maintaining annual production, a new plantation, established and cultivated like the original, may be started four or five years before the first has ceased yielding. This plantation in turn will continue to yield over a period of several years.

It is not practical to replace trees obtained by thinning a forest or timber plantation, as the young transplants would be seriously overtopped and shaded out by the older trees.

STATE FORESTRY AGENCIES

Woodland owners who desire more definite information regarding local forestry problems will do well to consult State forestry agencies as follows:

Alabama: State Forester, Montgomery, Ala.
Extension Forester, Alabama Polytechnic Institute, Auburn, Ala.
Arkansas: Extension Forester, 310 Federal Bank and Trust Building, Little Rock, Ark.
California: State Forester, Sacramento, Calif.
Extension Forester, College of Agriculture, University of California, Berkeley, Calif.
Colorado: Department of Forestry, Colorado Agricultural College, Fort Collins, Colo.
Connecticut: State Forester, Hartford, Conn.
Extension Forester, Connecticut Agricultural College, Storrs, Conn.
Delaware: State Forester, Dover, Del.
Florida: State Forester, Tallahassee, Fla.
Georgia: State Forester, State Capitol, Atlanta, Ga.
Extension Forester, State College of Agriculture, Athens, Ga.
Idaho: State Forester, Moscow, Idaho.
Extension Forester, College of Agriculture, Moscow, Idaho.
Illinois: Chief Forester, Springfield, Ill.
Extension Forester, College of Agriculture, University of Illinois, Urbana, Ill.
Indiana: State Forester, Indianapolis, Ind.
Extension Forester, Purdue University, Lafayette, Ind.
Iowa: State Forestry Commissioner, Des Moines, Iowa.
Extension Forester, Iowa State College of Agriculture, Ames, Iowa.
Kansas: State Forester, Manhattan, Kans.
Kentucky: State Forester, Frankfort, Ky.

Louisiana: Superintendent of Forestry, New Orleans, La.
Extension Forester, Louisiana State University, Baton Rouge, La.
Maine: Forest Commissioner, Augusta, Me.
Extension Forester, College of Agriculture, University of Maine, Orono, Me.
Maryland: State Forester, 1411 Fidelity Building, Baltimore, Md.
Extension Forester, University of Maryland, College Park, Md.
Massachusetts: State Forester, Statehouse, Boston, Mass.
Extension Forester, Statehouse, Boston, Mass.
Michigan: State Forester, Lansing Mich.
Extension Forester, Michigan State College, East Lansing, Mich.
School of Forestry and Conservation, University of Michigan, Ann Arbor, Mich.
Minnesota: Commissioner of Forestry and Fire Prevention, St. Paul Minn.
Extension Forester, Department of Agriculture, University of Minnesota, University Farm, St. Paul, Minn.
Mississippi: State Forester, Jackson, Miss.
Extension Forester, Jackson, Miss.
Missouri: State Forester, Columbia, Mo.
Montana: State Forester, Missoula, Mont.
School of Forestry, University of Montana, Missoula, Mont.
Nebraska: Extension Forester, College of Agriculture, Lincoln, Nebr.
New Hampshire: State Forester, Concord, N. H.
Extension Forester, University of New Hampshire, Durham, N. H.
New Jersey: State Forester, State Office Building, Trenton, N. J.
Extension Forester, College of Agriculture, New Brunswick, N. J.
New York: Superintendent Lands and Forests, Albany, N. Y.
Extension Forester, College of Agriculture, Cornell University, Ithaca, N. Y.
New York State College of Forestry, Syracuse, N. Y.
North Carolina: State Forester, Raleigh, N. C.
Extension Forester, State College Station, Raleigh, N. C.
North Dakota: State Forester, Bottineau, N. Dak.
Extension Forester, Bottineau, N. Dak.
Ohio: State Forester, Wooster, Ohio.
Extension Forester, Agricultural Experiment Station, Wooster, Ohio.
Oklahoma: State Forester, Oklahoma City, Okla.
Oregon: State Forester, Salem, Oreg.
School of Forestry, Oregon State College, Corvallis, Oreg.
Pennsylvania: State Forester, Harrisburg, Pa.
Extension Forester, Pennsylvania State College, State College, Pa.
Rhode Island: Chief, Bureau of Forestry, Statehouse, Providence, R. I.
South Carolina: State Forester, State Office Building, Columbia, S. C.
South Dakota: State Forest Supervisor, Custer, S. Dak.
Tennessee: State Forester, Nashville, Tenn.
Extension Forester, College of Agriculture, University of Tennessee, Knoxville, Tenn.
Texas: Director, Texas Forest Service, College Station, Tex.
Farm Forester, College of Agriculture, College Station, Tex.
Utah: Extension Forester, Agricultural College of Utah, Logan, Utah.
Vermont: Commissioner of Forestry, Montpelier, Vt.
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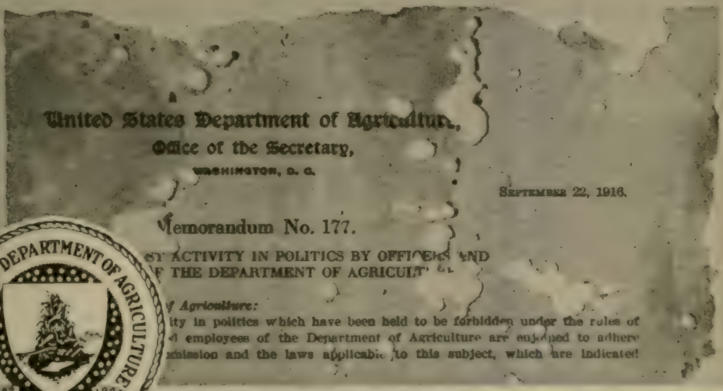
U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1665

THE SILVERFISH
AS A PEST OF THE HOUSEHOLD



United States Department of Agriculture,
Office of the Secretary,
WASHINGTON, D. C.

SEPTEMBER 22, 1916.

Memorandum No. 177.

ACTIVITY IN POLITICS BY OFFICERS AND
THE DEPARTMENT OF AGRICULTURE

of Agriculture:

ity in politics which have been held to be forbidden under the rules of
employees of the Department of Agriculture are enjoined to adhere
mission and the laws applicable to this subject, which are indicated

1862 1889

THE SILVERFISH OR SLICKER is a common cosmopolitan insect. Its importance as a household pest has increased many fold during the past few years, presumably because of the more general use of heat. In hotel and apartment house basements it seems to find modern conditions most favorable for its increase to tremendous numbers. Under such conditions its spread to the upper floors has been known to interfere seriously with the leasing of rooms, thus affecting the income from investment. Usually such articles as starched or sized fabrics, bookbindings, glazed paper, and wall paper are not eaten except under conditions of neglect or storage or in rooms closed for vacation periods. The persistent application of the control measures suggested in this bulletin should render control easy.

This bulletin is a revision of and supersedes Farmers' Bulletin No. 902, The Silverfish, or " Slicker," an Injurious Household Pest.

Washington, D. C. **June, 1931**

THE SILVERFISH AS A PEST OF THE HOUSEHOLD

By E. A. Back, *Principal Entomologist, in Charge, Division of Stored-Product Insects, Bureau of Entomology*

THE SILVERFISH (*Lepisma saccharina* L.) is that glistening, silver or pearl-gray insect with three long tail-like appendages (fig. 1) that is often seen when books, papers, clothing, or similar articles are suddenly moved. From the dark recesses thus exposed to light the silverfish glides quickly out of sight, often thwarting all attempts to catch it. In fact, this insect is an adept at dodging, and when actually in contact with the fingers, the slick, shiny body easily slips from the grasp. Because of its glistening body, its quick, gliding movements, and its ability to appear and as quickly and mysteriously disappear, it has received a number of popular names, among which are silverfish, slicker, silver louse, silver witch, sugarfish, woodfish, paper moth, and bristle-tail. It is well-nigh cosmopolitan in its distribution.

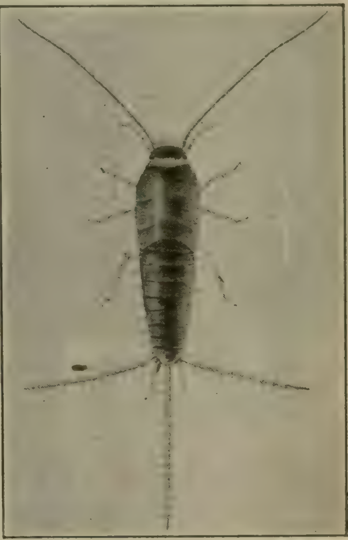


Figure 1.—Adult silverfish, about two and one-fourth times natural size. (Marlatt)

There are a number of different kinds of silverfish, perhaps the most common, aside from the subject of this bulletin, being the fire brat (*Thermobia domestica* (Pack.)). This is a heat-loving species that is to be found in greatest numbers about fireplaces and bake ovens and may be distinguished from the common silverfish by the dusky markings on its back.

HABITS OF THE SILVERFISH

Because the silverfish usually shuns the light and can run very rapidly to places of concealment, it is not often seen and may become very abundant and cause considerable injury before its presence is noticed.

The importance of the insect as a household pest has increased many fold during the last few years. This appears to be due to the more extended practice of having private homes evenly heated and to the unusually favorable environment for silverfish created by the basement conditions often existing in large apartment houses and hotels. Silverfish may be unusually troublesome in newly built establishments before the masonry has completely dried out. The walls of furnace rooms and near-by warm storage spaces may seem to be swarming with these insects which migrate along the plumbing to the floors above. In large apartment houses and hotels silverfish may become so abundant in rooms on the lower floors as to make it difficult to keep them rented.

In private homes silverfish are more apt to be troublesome in libraries and storage rooms, and particularly in attics. Though they prefer hot, damp locations, they become abundant and cause injury in country houses in cool, damp rooms that are never heated. Being nocturnal in habits they may never be observed by the housewife unless they become trapped in bathtubs, washbowls, or dishes into which they have fallen, but up the slick sides of which they can not climb.

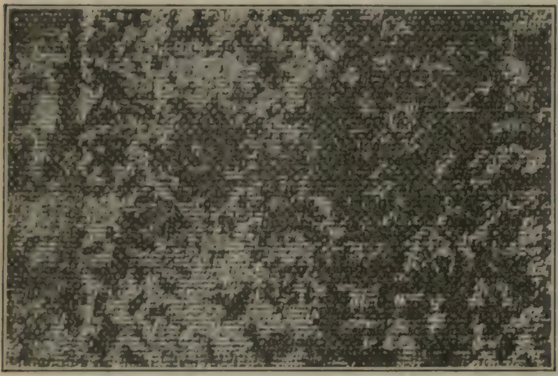


FIGURE 2.—Feeding of silverfish on sizing in the cloth binding of a book

NATURE OF INJURY

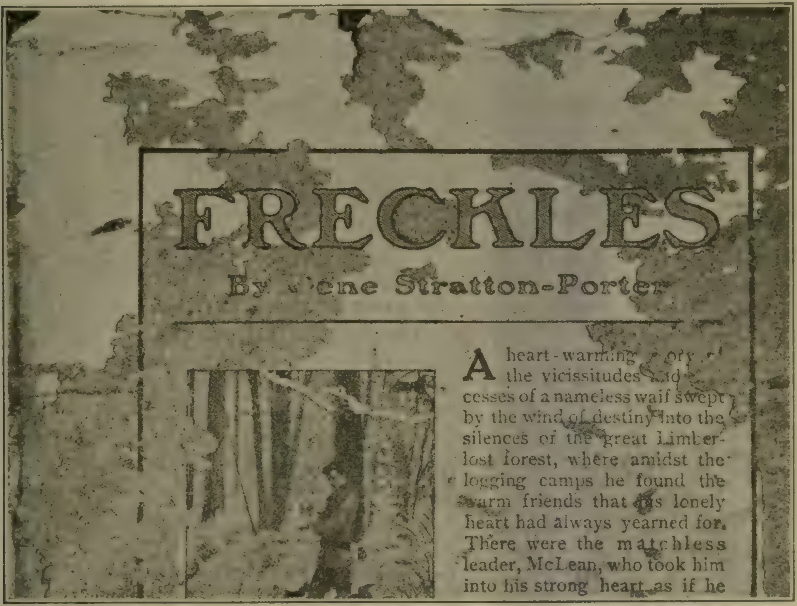
The silverfish is one of the most serious pests of libraries, being particularly destructive to the binding of books. It frequently eats off the gold lettering to get at the paste beneath, or gnaws off the label slips glued on the backs of books. Heavily glazed paper is sometimes disfigured or destroyed by the feeding of this pest upon their surfaces. In some cases books and magazines printed on heavily sized paper will have the exposed surface of the leaves a good deal scraped and even those portions covered by the ink may be attacked. Sometimes the paper is entirely consumed. (Figs. 2, 3, and 4.)

The silverfish will also eat any starched clothing, linens, or lace or muslin curtains, and has been known to do very serious damage to silks and rayons which have been stiffened with sizing. By eating the paste from the back of wall paper the silverfish sometimes causes the paper to scale off and become riddled with holes. The pest has been reported as feeding upon carpets, plush coverings of furniture, window shades, and even upon certain vegetable drugs. When abundant in dining rooms it would seem that it is interested in crumbs that lodge in the rugs rather than in eating the rugs themselves.

It is seldom that the silverfish causes damage except where the material it would eat has been left undisturbed for long periods packed away in drawers, closets, bookcases, or other such places. It likes warmth and does little damage during winter in the North, although in the South it is active the year around.

SILVERFISH AND COAL SUPPLIES

The persistent belief in certain places that silverfish are brought in large numbers to apartment houses and smaller dwellings with the coal supply seems without foundation. By the end of summer the insect often has increased to large numbers in basements, where they find food in and about trash containers, incinerators, janitors' rooms, etc. When the fires are started in the fall, the heat causes the insects to become very active. They seek shelter in supplies of coal, thus giving the impression that they have come with the coal and are feeding upon it. They are often quite as abundant in basements of buildings heated by gas or oil burners.



FRECKLES

By [illegible]ene Stratton-Porter

A heart-warming [illegible]ory the vicissitudes [illegible] cesses of a nameless waif swept by the wind of destiny into the silences of the great Limberlost forest, where amidst the logging camps he found the warm friends that his lonely heart had always yearned for. There were the matchless leader, McLean, who took him into his strong heart as if he

FIGURE 3.—Feeding of silverfish on sizing in paper cover of a book

LIFE HISTORY

A thorough study has not been made of the biology of the silverfish. From available data, however, it would seem that in a temperate climate females lay from 6 to 10 eggs each in the late spring. In one instance under observation all egg laying was confined to the month of May. The small whitish eggs are laid in crevices and other out-of-the-way places or in the folds of stored-away clothing. Though they may adhere slightly to one another and to the material upon which they are laid they are easily dislodged by brushing. When temperatures range between 64° and 68° F. the eggs may not hatch for from 46 to 60 days after being laid, but in tropical climates they may hatch in from 6 to 10 days.

When first hatched the young silverfish closely resemble the parent insect and continue to do so throughout immature life. In tropical climates they may become mature in from seven to nine months, but in temperate climates they require about two years to reach maturity. Larvae hatching in July, from eggs laid in May, have been known to pass two winters in the immature state. The females among these specimens matured and began laying eggs in May of the second year, and died not later than August of that year.

Adult specimens have been kept alive without food for as long as 319 days, whereas many given an opportunity to feed have been found alive after 327 days. It would seem that silverfish develop very slowly and have few young, but are very hardy and able to subsist under unfavorable food conditions for long periods.

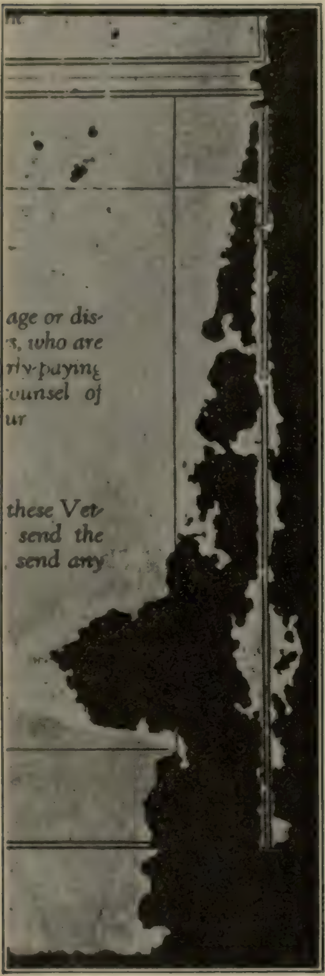


FIGURE 4.—Destruction of a printed page by silverfish

REMEDIES

Silverfish are not difficult to control. By taking advantage of their natural craving for starchy food, they can be poisoned by using a powder consisting of a mixture of 12 parts of sodium fluoride powder to 100 parts of wheat flour, or a thin paste made by mixing from one-half to three-fourths of an ounce of white arsenic with 1 pint of wheat flour and adding enough water to make a thin paste by boiling. The paste should be poured on small pieces of flexible cardboard or paper which later can be rolled into cylinders with the paste on the inside. The powder or paste should be put in out-of-the-way places where silverfish are found—on shelves, behind books, back of mantels, under washboards, and on the bottoms of drawers and in storage boxes. As both are poisonous they should be put where young children will not find them.

Pyrethrum, or buhach powder, dusted upon bookshelves or other places where it can be used, is of value; but it must be renewed often, for it loses its strength after long exposure to air.

For quickly killing hordes of silverfish found overrunning basements and furnace and storage rooms, spray with a saturated solution of paradichlorobenzene in carbon tetrachloride. As the carbon tetrachloride evaporates fine crystals of paradichlorobenzene will form on the sprayed objects, but these in turn will soon evaporate, causing no damage. If the room sprayed with the carbon tetrachloride-paradichlorobenzene mixture can be closed for 24 hours the results will be better. For starched clothing and similar objects liable to injury, frequent handling and airing and the destruction of any insects found are to be recommended, in addition to the remedies noted above.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1666

INSECTICIDES, EQUIPMENT, AND METHODS FOR CONTROLLING ORCHARD INSECT PESTS

1862 1889

FOR THE SUCCESSFUL growing of fruit it is essential to keep down the numbers of insect pests that would otherwise render a large part of the crop unmarketable or even useless for any purpose.

A great many ways of combating fruit insects have been developed, based on the varied habits of the different insects. Some must be attacked through poisoning their food, others by actually touching them with the death-dealing spray or dust, and still others by preventing them from reaching their goal, or even digging them out of their retreats.

This bulletin describes the insecticides and treatments that are at present giving the best results against the more important insect pests of the orchard, and tells at what season these treatments may be most effectively applied. Various types of dusting and spraying apparatus, nozzles, etc., are described and illustrated. Both those intended for use about the home grounds and those for large commercial orchards are discussed.

The more common fruit pests and the nature of the damage they do are described, and for each the proper control measures are given, with schedules for spraying the apple, peach, cherry, plum, and grape.

This bulletin is a revision of and supersedes Farmers Bulletin No. 908, Information for Fruit Growers about Insecticides, Spraying Apparatus, and Important Insect Pests.

Washington, D. C. **Issued September, 1931**

INSECTICIDES, EQUIPMENT, AND METHODS FOR CONTROLLING ORCHARD INSECT PESTS

By A. L. Quaintance,[1] formerly *Associate Chief of Bureau in charge*, and E. H. Siegler, *Senior Entomologist, Division of Deciduous Fruit Insects, Bureau of Entomology*

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NECESSITY OF CONTROLLING FRUIT INSECTS

INSECT CONTROL in orchards and vineyards is largely effected by spraying, and the needs of the fruit grower in the protection of his crops from the attack of insects and fungi [2] have been the predominating factors in the development of the present excellent lists of insecticides and a variety of spraying apparatus.

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[1] Resigned Dec. 31, 1930.

[2] The statements in this bulletin as to the use of fungicides are made with the approval of the Bureau of Plant Industry, U. S. Department of Agriculture.

Although spraying is one of the more expensive of the several orchard operations, the value of the crop is so greatly increased thereby that it is a comparatively small investment, the expense amounting to only a fraction of the returns directly due to the practice. Orchard spraying is, in fact, an exceedingly cheap form of insurance.

It must not be inferred, however, that spraying operations are uniformly successful. While a considerable degree of skill in spraying has now been reached by a large proportion of fruit growers, there is still room for much improvement. Of all orchard work, spraying is most likely to be slighted or even neglected, and fruit growers need to have a more intimate knowledge of spraying materials, spraying machinery, and especially the whys and wherefores of spraying.

The term "spraying," unfortunately, has come to have a general meaning, and it is apparent that some fruit growers do not yet understand that the kind of spray and the manner of application depend upon the character of insect or insects to be controlled. The up-to-date orchardist will know just what each spray application is intended to do and will realize the importance of spraying at the proper time and in the proper way. A better understanding on the part of fruit growers of the life and habits of the insect pests of their crops and of the nature of insecticides will add much to the efficiency of their work in fighting them.

There are several important insect pests, however, for which spraying does not give protection, and the control of these must not be overlooked by the orchardist. Of these the most serious are certain species of borers, which are best destroyed by systematic "worming," once or twice each year. The great desirability of keeping insects reduced by up-to-date orchard practice, as fertilization, thorough cultivation, and attention to pruning and other operations can not be emphasized too strongly and is well appreciated by our most progressive and successful growers.

HOW INSECTS FEED

A knowledge of the character of the mouth parts of insects is of importance to the fruit grower, for the type of mouth part determines the general character of sprays to be used. Broadly speaking, all insects secure their food in one of two ways: (1) by actually biting out and swallowing portions of the food material; or (2) by sucking out the juices from the interior portions of the plant. The few exceptions to this general statement are unimportant in the present connection.

Biting and sucking types of mouth parts are on two quite distinct plans. In the former there are two horny, opposable jaws, working sideways, and certain accessory appendages, with which particles of the leaf, bud, fruit, or other food substance are cut out and passed on as more or less solid particles to the food canal for digestion. This type is found in several orders of insects, as in caterpillars, or the larvae of moths and butterflies, adult beetles and their grubs, grasshoppers, crickets, sawfly larvae, etc. (Fig. 1.)

Biting insects in general may be destroyed with arsenicals or other stomach poisons. Some biting insects, such as borers and certain root-infesting forms, do not feed in situations where they can be reached by poisons, and for these a different treatment is necessary.

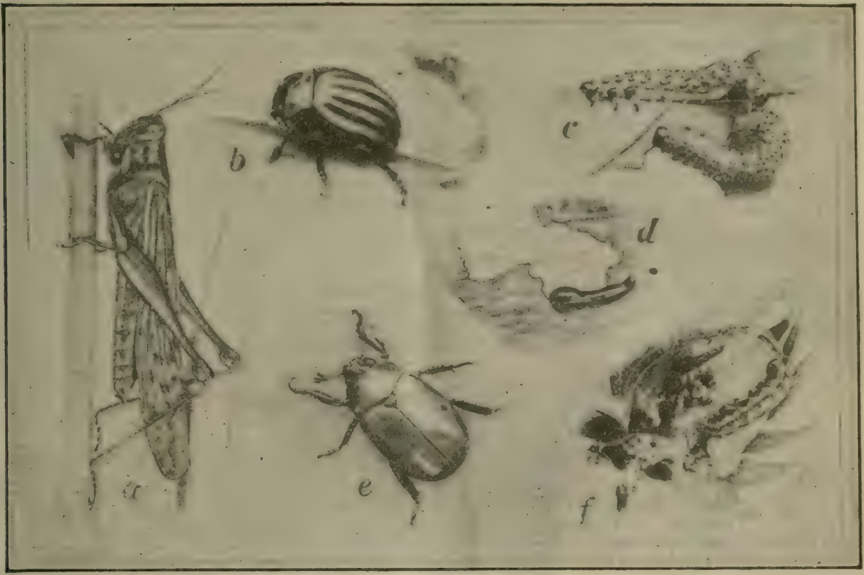

FIGURE 1.—Examples of insects with biting mouth parts: *a*, Grasshopper; *b*, *e*, beetles; *c*, *d*, sawfly larvae; *f*, caterpillar. These insects feed by biting off and swallowing pieces of their food

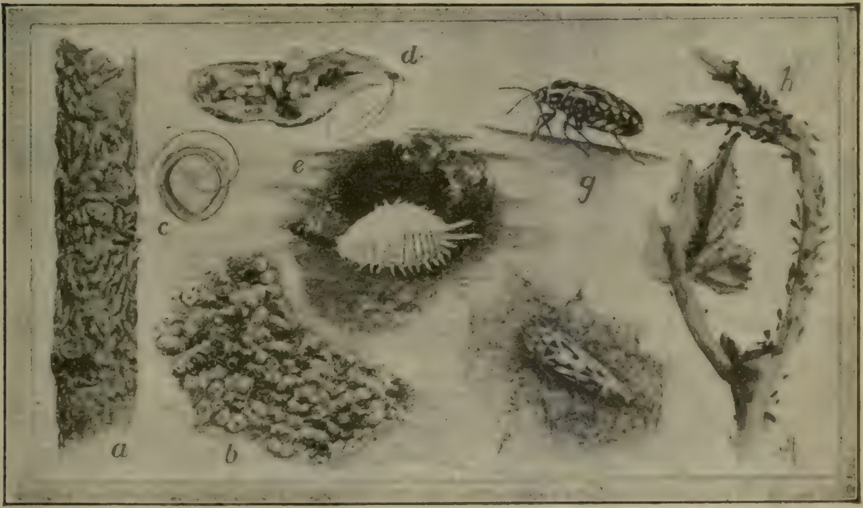

FIGURE 2.—Examples of insects with sucking mouth parts: *a–e*, Scale insects; *f*, leaf hopper; *g*, plant bug; *h*, aphids. These insects feed by sucking the juices from the plants

In most sucking insects of economic importance to the fruit grower, the mandibles and maxillae are drawn out into long setae, or bristles, which are inclosed in a greatly modified tubelike lower lip, or beak, the four setae and beak constituting a sucking apparatus with which juices may be drawn up from plants. Plant lice, scale insects, leaf hoppers, the pear psylla, and the true bugs, very important enemies of the fruit grower, are sucking insects (fig. 2), and for their control the so-called contact sprays are used, which corrode the body or penetrate the breathing pores of the pests or otherwise effect their destruction by direct contact.

Biting and sucking insects often live in places which permit of their practical destruction by poisoning the air which they breathe, as with hydrocyanic acid gas or carbon disulphide. The fumigation of trees with hydrocyanic acid gas is extensively practiced in California for the destruction of scale insects infesting citrus trees, and to a less extent elsewhere. The use of this gas in the control of deciduous-fruit insects has been thoroughly investigated and on account of its cost has been discontinued in favor of spraying. Nursery stock, however, is now regularly fumigated by most nurserymen to guard against the possible dissemination of injurious insects (p. 29).

SPRAYING DORMANT TREES

The spraying of deciduous-fruit trees during winter and spring, when they are in a dormant condition, is directed largely against scale insects, especially the San Jose scale (*Aspidiotus perniciosus* Comst.) (p. 63). There are two principal advantages in spraying at this time: (1) The absence of foliage permits of more thorough applications; and (2) the sprays may be used at much greater strength than during the growing season. Contact sprays are employed, as lubricating-oil emulsions, lime-sulphur solution, miscible oils, and to a limited extent fish-oil soap and other soap washes. The prime essential is thoroughness in making applications, so as to cover every part of the tree, because in general only those insects actually hit with the spray are killed.

Applications may be made in late fall as soon as most of the leaves have fallen, at favorable times during the winter when the temperature is above the freezing point, or, preferably, in the spring shortly before the buds are due to swell. There is probably less danger to fruit buds and twigs from the use of sprays in the early spring than at other times, especially in the case of the lubricating-oil emulsions and miscible oils. Better results follow spraying with lime-sulphur solution in late spring than in late fall or during the winter, since this insures some spray on the trees during early summer, which is of value in killing any young scales, the offspring of adults which may have escaped destruction.

Spraying dormant trees for the San Jose and other scales and for other insect pests has come to be a very important part of orchard work, and it is usually possible so to time this work that a single application will reach most of the troubles that may be controlled by dormant-tree sprays. Other things being equal, the insecticide having the greatest range of usefulness should be employed. In most sections of the country lubricating-oil sprays have come into rather general use against the San Jose scale, and they are on the whole more effective than lime-sulphur against a number of other scale insects which may also infest the trees. Included among these are most other diaspine scales, as the cherry scale (*Aspidiotus forbesi*

Johnson), the walnut scale (*A. juglans-regiae* Comst.), the West Indian peach scale (*Diaspis pentagona* Targ.), the European fruit scale (*A. ostreaeformis* Curt.); and the lecanium scales, such as the terrapin scale (*Eulecanium nigrofasciatum* Perg.) and the brown apricot scale (*Lecanium corni* Bouché). The lubricating-oil emulsions are reasonably effective against the oyster-shell scale (*Lepidosaphes ulmi* L.) and the scurfy scale (*Chionaspis furfura* Fitch). In addition, the eggs of the European red mite (*Paratetranychus pilosus* C. and F.), of the fruit-tree leaf roller (*Cacoecia argyrospila* Walk.), and several stages of the pear psylla (*Psyllia pyricola* Först.), are more readily controllable by the use of oil sprays than by the use of lime-sulphur. Lime-sulphur, on the other hand, is quite effective against most of the scale insects listed above, is more effective than oil against the pear-leaf blister mite (*Eriophyes pyri* Pgst.), and with nicotine in the delayed dormant (p. 66) is the most completely effective spray against the apple and other aphids. Lime-sulphur has the further advantage of being an excellent fungicide, but it is somewhat disagreeable to handle.

SUMMER SPRAYING

By summer spraying is meant the application of spray materials during the period when the trees are in foliage. The work is directed principally against bud, leaf, and fruit eating insects; and for these arsenicals chiefly are used. Dilute contact insecticides also are employed in the control of certain sucking insects, as aphids, red bugs, leaf hoppers, etc.

The arsenical in most general use is lead arsenate, although calcium arsenate is also used to some extent. The foliage of stone fruits, as cherry, plum, and peach, is on the whole quite tender, and on these, arsenicals must be employed with caution. Lead arsenate is least likely to do harm, though more than two applications, especially to peach, may cause shot-holing and dropping of leaves, twig injury, and burning of the fruit.

Summer spraying is now almost universally employed in the commercial production of apples, peaches, and grapes, and spraying schedules have been arranged which are effective in the control of, or greatly reduce the losses caused by, the principal insect and fungous diseases of the fruit and foliage of these trees. (See pp. 71, 80, 83, 84, 89.)

GENERAL CLASSIFICATION OF INSECTICIDES

As already indicated, the important insecticides may be grouped principally into three series, as follows:

Insecticides for biting insects (*stomach poisons*).—Lead arsenate, calcium arsenate, and, to a much lesser extent, Paris green, are the principal stomach poisons used against insects that bite and chew their food. Hellebore is occasionally used on fruit which is about ready to be picked, especially on currants. Sodium arsenite, sodium arsenate, and white arsenic are used in poisoned baits, but are highly injurious to foliage, and consequently can not be used in foliage sprays. Several fluorine compounds, such as sodium fluosilicate, barium fluosilicate, potassium fluosilicate, potassium aluminum fluoride, and sodium aluminum fluoride (cryolite) are being used in an experimental way, but as yet have not found a permanent place in orchard spraying.

Insecticides for sucking insects (contact sprays).—For insects that suck the plant juices contact sprays are used. The more important of these are lime-sulphur solution, lubricating-oil emulsions, miscible oils, kerosene and distillate emulsions, nicotine solutions, pyrethrum extracts, and derris extracts. Self-boiled lime-sulphur also has more or less value as a contact insecticide. Soap, caustic soda, caustic potash, and carbolic acid emulsion are occasionally used.

Fumigants.—Hydrocyanic acid gas, carbon disulphide, paradichlorobenzene, sulphur dioxide, etc., are effective against all classes of insects when it is feasible to use them.

STOMACH POISONS

ARSENICAL INSECTICIDES

LEAD ARSENATE

Lead arsenate is the best known and most extensively used stomach poison for insects, and it has a wider range of usefulness than has any other internal poison now available. It is safe for use on the foliage of most plants, possesses good adhesive qualities, and owing to its fineness remains in suspension well in water. Moreover, it can be safely combined with certain contact sprays, as nicotine, kerosene emulsion, etc., and with a number of fungicides, such as lime-sulphur solution, self-boiled lime-sulphur mixture, and Bordeaux mixture. It should not, however, be combined with sodium or potassium sulphides.

Lead arsenate is now available chiefly as a dry, fluffy powder, which has largely replaced the old paste form by reason of the convenience with which the dry material may be handled and stored, and the saving in transportation costs by the absence of water. Unless otherwise stated, the term "lead arsenate" in this bulletin refers to the dry form of acid lead arsenate. The paste form contains approximately 50 per cent of water, and twice as much should be used as of the dry form. Although nearly all the lead arsenate on the market to-day is the acid lead arsenate, a second form, known commercially as basic, tri-plumbic, or orthoarsenate, is less injurious to foliage. For this reason basic lead arsenate is used in spraying the sensitive foliage of the English walnut and is occasionally recommended for use on peach, plum, and other stone fruits. However, it is less rapid in its killing effect than is acid lead arsenate.

Lead arsenate is a standard product, and practically all brands contain at least 30 per cent of arsenic pentoxide (As_2O_5), and not more than three-fourths of 1 per cent of water-soluble arsenic.

DIRECTIONS FOR USE

Lead arsenate should be mixed into a thin paste with water before being added to the spray tank, although some growers sift it or work it through the screen as the spray tank is being filled. If paste lead arsenate is used, it should be thinned with a little water before it is added to the spray tank. For the control of most chewing insects which destroy deciduous-fruit crops, lead arsenate is used at a strength of 1 pound in 50 gallons of water, although for some insects a greater strength is desirable.

When lead arsenate is used on peach foliage, 4 pounds of hydrated lime, or the milk of lime made by slaking 3 pounds of stone lime, should be added to each 50 gallons of water in order to reduce the danger of injury to the foliage. In many sections of the country, especially in the humid regions, this practice is also followed in spraying apples. When lead arsenate is used with a fungicide containing an excess of lime, the further addition of lime is unnecessary.

CALCIUM ARSENATE

Calcium arsenate, or arsenate of lime, is a compound somewhat similar to lead arsenate, in which the arsenic has been combined with lime instead of with lead. This material usually contains from 42 to 46 per cent of arsenic pentoxide. In addition to containing a higher percentage of arsenic than lead arsenate, calcium arsenate is somewhat cheaper on the pound basis. It is much more likely to injure foliage than is lead arsenate, and is unsafe for use on peach, cherry, plum, and other stone fruits. Even when used on resistant foliage, such as that of the apple, pear, and grape, injury has frequently been reported, and as a result this stomach poison is not in very general use against orchard insects. Calcium arsenate has also been found less effective than lead arsenate against the codling moth (*Carpocapsa pomonella* L.), although against many other insects the two appear to be about equally effective.

DIRECTIONS FOR USE

The same directions as have been given on page 6 for mixing lead arsenate for spraying should be followed in preparing calcium arsenate. For most chewing insects it is used at a strength of three-fourths of a pound in 50 gallons of spray. The risk of foliage injury may be considerably reduced by adding 4 pounds of hydrated lime or 3 pounds of stone lime (which should first be slaked). If Bordeaux mixture is being used with the insecticide, the addition of more lime is unnecessary.

PARIS GREEN

Paris green is an arsenical compound, the aceto-arsenite of copper, and was one of the first poisons used in the United States for the destruction of chewing insects. Paris green has been widely and extensively employed in the past, but in recent orchard spraying it has been largely superseded by lead arsenate.

Commercial Paris green should be finely ground, and as specified by the insecticide act of 1910 should contain not less than 50 per cent of arsenious oxide and not more than 3½ per cent of water-soluble arsenic. It is a heavy substance, and thorough agitation is therefore necessary in order to secure even distribution of the poison when applied as a liquid spray. It is not so adhesive as lead arsenate, though when used in Bordeaux mixture this objection loses much of its force.

Paris green should never be used on stone fruits, such as peaches, cherries, or plums. When used on apples, pears, grapes, or foliage having similar resistance to arsenical scorching, Paris green should be combined with either Bordeaux mixture or milk of lime. It should not be mixed with lime-sulphur solutions. Paris green is ordinarily used in the proportion of 6 ounces in 50 gallons of water.

ZINC ARSENITE

Zinc arsenite was placed upon the market a few years ago in both paste and powder forms. The powdered zinc arsenite usually contains slightly over 40 per cent of arsenious oxide. In common with other arsenious compounds, zinc arsenite is an active poison, but it can not be used with safety except on very resistant plants. The danger of burning is reduced when this poison is combined with milk of lime or Bordeaux mixture. Zinc arsenite (powder) is generally used in the proportion of three-fourths pound to each 50 gallons.

LONDON PURPLE

London purple is a by-product in the manufacture of aniline dyes and contains a variable amount of arsenite of lime. It was formerly used as a substitute for Paris green, but owing to its variable composition, its high water-soluble arsenic content, and the resultant injury to the plant foliage, London purple is now seldom used in orchard spraying.

WHITE ARSENIC (ARSENIC TRIOXIDE)

White arsenic is an exceedingly active stomach poison and is generally employed in the manufacture of the arsenical poisons now in use. Owing to its causticity it can not be used as a spray material without severe burning of the foliage. White arsenic is used to some extent as a poison in insect baits.

ARSENICAL INSECT BAITS

Poisoned baits have proved very valuable for emergency purposes, especially to combat serious outbreaks of grasshoppers, cutworms, etc. These insects sometimes defoliate fruit trees, although grasses and grains usually suffer the most from them.

Insect baits made according to several formulas have been recommended, but those composed of poisoned bran sweetened with a sirup have been most extensively employed. These baits are easily made, reliable, cheap, and very effective. While they may vary somewhat in composition, a good standard bait for grasshoppers can be prepared as follows:

Wheat bran	pounds	100
Sodium arsenite solution (8-pound material)[3]	quart	1
Amyl acetate	ounces	3
Blackstrap cane molasses	gallons	2
Water	do	12

Mix thoroughly the water, molasses, amyl acetate, and sodium arsenite, and moisten the bran with this mixture. The bran may be mixed either by hand or machine, very much as cement is mixed.

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[3] Sodium arsenite solution is on the market under a number of trade names, and is sold largely for use as a weed killer. The term "8-pound material" means that the solution contains the equivalent of 8 pounds of white arsenic per gallon. This form is more economical to use than the weaker solutions. In case the dry sodium arsenite powder is more readily obtainable, 4 pounds of it may be substituted for the quart of liquid sodium arsenite in the formula.

The resulting mash must be well mixed—not too wet, for it should crumble easily when scattered. The mash is scattered broadcast by hand at the rate of from 10 to 12 pounds per acre, wet weight, before the middle of the forenoon, since the hoppers eat most greedily between 8 and 11 a. m.

HELLEBORE

Hellebore is the powdered roots of the white hellebore plant (*Veratrum album*).[4] It contains alkaloids which are poisonous to insects, but which in the quantities properly used for insecticides do not seriously affect people. For this reason it may be used to protect fruit that is about to ripen, from injury by chewing insects. This material, however, is used only for small-scale operations, as it can not be profitably employed where many plants are to be treated.

Liquid application:

Hellebore	ounce	1
Water	gallon	1

Dry application:

Hellebore	ounce	1
Flour (or air-slaked lime)	ounce	5 to 10

POWDERS FOR DUSTING

Insecticides and fungicides in dry or powdered form have long been used in insect and disease control, especially on low-growing plants. Interest has been manifested at different times in the use of dusts for the control of these troubles in orchards and vineyards, and extensive experiments have been made to determine the efficacy of such treatments. The dusts originally used in orchards were mostly composed of dry Bordeaux materials and Paris green. These dusts, on the whole, did not prove satisfactory substitutes for spraying and were little used, except under unusual orchard conditions. From time to time during the last 15 or 20 years a great deal of further work has been done with dusting, by experimental workers as well as by commercial fruit growers.

The material now used is finely powdered lead arsenate, usually with either a very finely divided sulphur or copper fungicide. The lead arsenate content ranges from 5 to 15 per cent, depending on the insect to be controlled and the plant to be treated. Occasionally, when the copper fungicides are used, calcium arsenate is substituted for the lead arsenate. In case no fungicide is needed, or a reduced quantity will accomplish the purpose intended, the bulk of the dust is increased by the addition of more or less of an inert filler, as hydrated lime, gypsum, or finely divided clay. Dusts containing nicotine, or calcium cyanide, to be discussed later, have also been used in orchards to a limited extent.

The application of insecticides and fungicides in the form of dusts, instead of diluted with water, has certain very definite advantages. Lighter machinery may be used, since the spray tank with its load of three-fourths of a ton or more of liquid is replaced by a light hopper and 100 to 200 pounds of dust; this is an important factor in rough, hilly orchards, or on soft ground. Dusting is especially useful in orchards which have an inadequate or an inconvenient water supply. The dusting method permits the covering of the planting much more rapidly than is possible with a sprayer, a decided advantage when large acreages must be treated within a limited period of time. The saving in labor costs, however, is offset by the greater cost for the dust materials, and the total costs of the two forms of application are approximately the same.

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[4] Our native plant, *V. viride*, possesses about the same insecticidal properties as white hellebore and is now being used to some extent for insecticidal purposes.

Under conditions of light or moderate infestation, dusting gives results nearly as good as those obtained by liquid spraying, and orchard dusting for insect control is most common in regions where the insect pests are not especially difficult to hold in check. When combating severe infestations of many insects, particularly of the codling moth or plum curculio, however, dusting has been found distinctly less effective than spraying. Many growers with extensive acreages utilize dusting as a supplement to spraying, to cover the ground quickly when there is not time for the slower operation of spraying, or for the rougher, more hilly portions of the orchards, where a heavy sprayer can not be conveniently used. Unfortunately, dusting with fungicides for various fruit diseases has not proven very effective, especially during years of serious infection. Where the usual practice of combining insecticides and fungicides is followed, liquid applications will be found more satisfactory than dusts. Dusts are to be used only on trees in foliage. For dormant tree treatment for the San Jose and other scales, sprays must be used.

QUANTITY OF DUST MATERIAL REQUIRED

Under average conditions about 2 pounds of the dust mixture will cover the same tree area as 10 gallons of liquid spray. The quantity of dust necessary for thorough work, however, will vary somewhat, depending upon air currents and whether these are variable or uniform in direction, the size and shape of the trees, the distance between the trees, and other factors.

APPLYING THE DUST

The dust material should be applied during very calm weather, as it is practically impossible to treat an orchard properly when the wind is strong. In recent years some growers have equipped their outfits with lights so as to apply the dusts during the night, when wind movement is at a minimum. Small trees may sometimes be well treated by dusting from one side only, but trees of moderate to large size must be dusted from two sides in order that they may be covered properly. As a general practice it is better to dust rapidly from two sides than to work slowly from one side. It is not necessary to apply the dust when the trees are wet with dew or rains, as the dust material will adhere to the dry foliage.

PREPARATION OF THE DUST

Dusts are readily made at home by weighing out the desired quantities of the respective ingredients and passing them through a mixing machine. Self-mixing dusting machines, however, are now available on the market. For small-scale work the mixing may be done by hand.

SPRAY RESIDUE

In recent years there has been an increasing belief that the indiscriminate use of poisonous materials on food products, such as apples, pears, grapes, etc., constitutes a potential menace to health. Though most insect pests may be satisfactorily controlled without leaving excessive spray residues, there are some sections of the country in which adequate protection from insects can not be accomplished without leaving considerable quantities of lead arsenate on the fruit at harvest time. This problem has been especially acute in the control of the codling moth in arid regions, and at present the difficulty with residue is being met by washing the fruit in dilute hydrochloric acid. Effective washing machinery has been devised which cleans the fruit at a fairly low cost. Nearly all of the apples grown in the Northwest are now being washed before being placed on the market, and other sections of the country are gradually adopting the process.

CONTACT SPRAYS AND DUSTS

SULPHUR SPRAYS

LIME-SULPHUR

As stated elsewhere, lime-sulphur sprays are of value in the control of the San Jose and certain other scales, as well as of numerous other insects. When the lime-sulphur solution is properly diluted it is a very valuable fungicide for use on hardy trees in foliage and at the same time will destroy many of the newly hatched San Jose and other scale insects. As a summer spray it may be combined with lead arsenate and nicotine for the simultaneous control of many chewing and sucking insects and fungous diseases. Lime-sulphur solution should not be used with soap.

OLD FORMULA

Several years ago the home-cooked lime-sulphur wash was largely used for the control of the San Jose scale, but it has now been generally superseded by the commercial or homemade concentrates. Since inquiry is occasionally received as to its preparation, the old formula and method of making are given below:

Stone lime	pounds	20 or 2
Sulphur (commercial ground)	do	15 or 1½
Water to make	gallons	50 or 5

Heat in a cooking barrel or vessel about one-third of the total quantity of water required. When the water is hot add all the lime and at once add all the sulphur, which previously should have been made into a thick paste with water. After the lime has slaked about another third of the water, preferably hot, should be added, and the cooking should be continued for one hour, when the final dilution may be made, using either hot or cold water as is most convenient. The boiling due to the slaking of the lime thoroughly mixes the ingredients at the start, but subsequent stirring is necessary if the wash is cooked by direct heat in kettles. If cooked by live steam no stirring will be necessary. After the wash has been prepared it must be well strained as it is being run into the spray tank. It may be cooked in large kettles or preferably by steam in barrels or tanks. This wash should be applied promptly after preparation, since, as made by this formula, there is crystallization of the sulphur compounds and consequent hardening of the sediment upon cooling.

COMMERCIAL LIME-SULPHUR CONCENTRATES

For a number of years manufacturers have had on the market concentrated solutions of lime-sulphur which have only to be diluted with water for use. These standard commercial preparations, if used at proper strengths, have proved to be entirely satisfactory and are now used by most growers in preference to the homemade material. Where only a limited amount of spraying is to be done, as in the average home orchard, it will be especially convenient to use the commercial product. Lime-sulphur concentrates usually may be purchased from local seedsmen, implement dealers, or druggists, or from the manufacturers. They should have a density of about 33° on the Baumé scale and at this strength should be used as follows:

For dormant trees, 6¼ gallons to make 50 gallons of spray, or 5 pints to make 5 gallons of spray.

For hardy trees in foliage, 1½ gallons to make 50 gallons of spray, or 1¼ pints to make 5 gallons of spray. Some growers use a lower strength of lime-sulphur for the spraying of trees in foliage, diluting the concentrate 1¼ gallons to 50, or even as weak as 1 to 50.

For the dilution of lime-sulphur concentrate of a different strength from the standard 32° to 33° Baumé see the dilution table of page 13.

HOMEMADE LIME-SULPHUR CONCENTRATES

The question of the preparation at home of a lime-sulphur concentrate which will not crystallize upon cooling, thus duplicating the commercial product, has been investigated by the Bureau of Entomology as well as by numerous experiment station entomologists, notably by Stewart, Cordley, Parrott, and others. It has been demonstrated that it is practicable for orchardists to prepare concentrated stock solutions of lime-sulphur for immediate or later use, and since there is a saving in costs, some orchardists employ this plan. The necessary details for the preparation at home of lime-sulphur concentrates will be found in Farmers' Bulletin 1285,[5] Lime-Sulphur Concentrate, Preparation, Uses, and Designs for Plants, and will not be given here.

HANDLING AND STORAGE OF LIME-SULPHUR CONCENTRATES

In case the grower prepares his own lime-sulphur concentrate, it is very desirable in most cases to make up a supply during the winter or early spring, before spraying operations begin. It is quite feasible to do this, as the concentrated solution can be kept a year or more when properly stored. It should be placed in barrels or other tight receptacles and carefully stoppered so as to exclude the air as much as possible, as this wash deteriorates slowly when in contact with the air. The barrels or other containers should be filled completely, so that there will be little or no air space above the contents. If the container is not filled completely, the concentrate should be covered with a layer of heavy oil or paraffin. In the preparation of the lime-sulphur concentrate at home the disposition of the sludge is a question of practical importance. Commercial manufacturing plants are usually equipped with a filter press by means of which the wash as it comes from the cooking tank is filtered, freeing it from sludge and sediment. There seems, however, to be no objection to storing the solution without removal of sludge, though the coarse sediment should be strained out before the material is used.

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[5] The bulletin may be obtained free on request to the U. S. Department of Agriculture.

Lime-sulphur concentrate freezes at temperatures considerably below the freezing point of water; the stronger concentrates do not begin to freeze until the temperature drops nearly to zero. The strength of the solution may not be affected by freezing, but in order to avoid damage to the receptacles by expansion the concentrate should be stored where the temperatures are likely to remain well above zero.

DILUTION

It is very important to test with a hydrometer (fig. 3) the strength of all lime-sulphur solutions, to determine the proper amount of the concentrate that should be used for a given quantity of water. There are two kinds of these hydrometers, one with the Baumé scale and the other with the specific-gravity scale, and hydrometers may be purchased which have both scales on the same instrument. The Baumé-scale hydrometer is most commonly used. The clear solution at a temperature of about 60° F. should be used for the testing. If, however, the sludge has not been filtered out, the contents of the barrel or other container should be thoroughly stirred before the required amount for testing is taken out. The amount of dilution for concentrates for each degree Baumé from 20 to 36 and the corresponding specific-gravity reading can be determined from Table 1.

Table 1.—*Proper dilution of concentrated lime-sulphur solutions for various strengths of spray*

Degrees Baumé	Specific gravity	Quantity [1] of concentrated lime-sulphur [2] to make 50 gallons spray solution at—				
		Summer or foliage strength of—			Winter or dormant strength for—	
		1 to 50	1¼ to 50	1½ to 50	San Jose scale	Blister mite
		Gallons	*Gallons*	*Gallons*	*Gallons*	*Gallons*
36	1.330	¾	1	1¼	5½	4¾
35	1.318	1	1	1¼	5¾	5
34	1.306	1	1¼	1½	6	5
33	1.295	1	1¼	1½	6¼	5¼
32	1.283	1	1¼	1½	6½	5½
31	1.272	1	1¼	1½	6¾	5¾
30	1.261	1	1¼	1¾	7	6
29	1.250	1¼	1½	1¾	7¼	6¼
28	1.239	1¼	1½	1¾	7½	6½
27	1.229	1¼	1½	2	8	6¾
26	1.218	1¼	1½	2	8½	7¼
25	1.208	1¼	1¾	2	8¾	7½
24	1.198	1½	1¾	2¼	9¼	8
23	1.188	1½	2	2¼	9¾	8¼
22	1.179	1½	2	2¼	10¼	8¾
21	1.169	1¾	2	2½	11	9¼
20	1.160	1¾	2¼	2½	11½	9¾

[1] All quantities expressed in nearest quarter gallon.

[2] 32° to 33° Baumé as standard strength.

In winter spraying for the San Jose scale and the pear-leaf blister mite about 5 per cent more of the solution should be used than the table of dilutions indicates, if the sludge has not been filtered out.

In summer spraying, however, no allowance for sludge is necessary, as a large percentage of this is composed of finely divided sulphur, which is of value.

LIME-SULPHUR SOLUTIONS FOR SUMMER SPRAYING OF POME FRUITS

Although used for the primary purpose of controlling fungous diseases, the summer strength lime-sulphur also assists a great deal in checking infestations of scale developing from individuals that may have escaped the dormant treatment, especially if the limbs, branches, and twigs are well coated, and will prevent to a large extent the infestation of fruit late in the season. Such infestation of fruit is very objectionable, especially on apples intended for export trade, as scale-infested fruit is excluded from entry by certain foreign governments and is discriminated against by buyers generally. The use of lime-sulphur as a summer spray does not, however, obviate the need of thorough dormant treatments for the San Jose scale where this insect is at all troublesome.

As already stated, the standard strength of lime-sulphur for summer spraying is 1½ gallons (of a con- 33° Baumé) in 50 gallons centrate registering 32° to of spray. For the benefit of growers who prefer to use weaker solutions the proper dilutions for strengths of 1 to 50 and 1¼ to 50 are indicated in the third and fourth columns of Table 1.

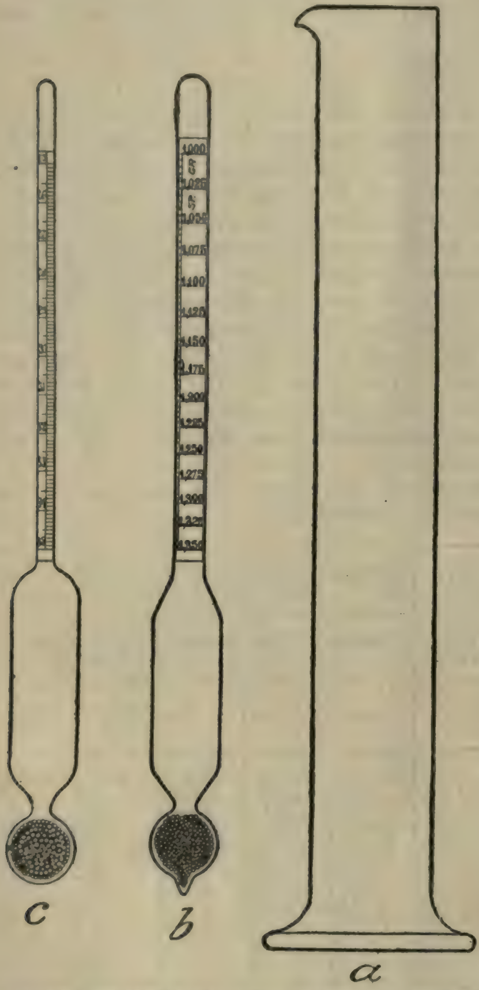

FIGURE 3.—Apparatus for determining specific gravity of lime-sulphur concentrate: *a*, Cylinder for liquid to be tested; *b*, specific-gravity spindle; *c*, Baumé spindle. The use of the hydrometer makes possible the dilution of the concentrate to exactly the proper strength

DRY LIME-SULPHUR

In recent years a dry form of lime-sulphur has become available on the market. This is prepared by the evaporation of ordinary lime-sulphur concentrate, with the addition of a stabilizer to prevent the breaking down of the higher polysulphides, which are said to constitute the most active part of lime-sulphur. Water is added to this to make a spray. The chief advantage of dry lime-sulphur is in the reduction of shipping costs and the increased ease and convenience with which the material may be handled without the added weight of water. Against the San Jose scale, however, dry lime-sulphur has proved less effective than the standard lime-sulphur concentrate[6] when the two are compared on the basis of an equal sulphur content and an equal degree of scale infestation.

SELF-BOILED LIME-SULPHUR MIXTURE FOR SUMMER SPRAYING OF STONE FRUITS

It may also be desirable to apply a summer spray to peach trees and other stone fruits for the San Jose and similar scale insects because of ineffective work during the dormant period of the trees. Under such circumstances the self-boiled lime-sulphur mixture should be used, since the foliage of most stone fruits will not stand the diluted lime-sulphur concentrate previously indicated for the apple, pear, etc. Self-boiled lime-sulphur is made up according to a formula quite different from any of the washes heretofore mentioned and has for a number of years been in general use as a fungicide for the control of peach scab and brown rot. Orchardists spraying for these troubles on peaches and other stone fruits may at the same time accomplish much in preventing the increase of the scale by thoroughly coating the limbs and branches of the trees while making the applications to the foliage and fruit.

The self-boiled lime-sulphur mixture may be made as follows:

Stone lime	pounds	8, or 2
Sulphur (commercial ground[7] or flowers)	do	8, or 2
Water to make	gallons	50, or 12½

The lime should be placed in a barrel and enough water poured on almost to cover it. As soon as the lime begins to slake, the sulphur should be added, after first running it through a sieve to break up the lumps. The mixture should be stirred constantly and more water added as needed to form at first a thick paste and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked, cold water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted, and applied.

The stage at which cold water should be poured on to stop the cooking varies with different grades of lime. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking, and care must be taken not to allow the boiling to proceed too far. If the mixture is allowed to remain hot 15 or 20 minutes after the slaking is completed, the sulphur gradually goes into solution combining with the lime to form sulphides, which are injurious to peach foliage. It is therefore very important, especially with hot lime, to cool the mixture quickly by adding a few buckets of water as soon as the lumps of lime have slaked down. The intense heat, violent boiling, and constant stirring result in a uniform mixture of finely divided sulphur and lime, with only a very small percentage of the sulphur in solution. It should be strained to take out the coarse particles of lime, but the finer particles of the mixture should be carefully worked through the strainer. Larger quantities can be prepared if desired, say enough for 200 gallons at a time, making the formula 32 pounds of lime and 32 pounds of sulphur to be slaked with a small quantity of water (8 or 10 gallons) and then diluted to 200 gallons. To make other quantitites of the mixture see the dilution table on page 61.

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[6] U. S. Department of Agriculture Bulletin 1371, Effectiveness Against the San Jose Scale of the Dry Substitutes for Liquid Lime-Sulphur.

[7] Commercial ground sulphur is the cheaper and is equally as satisfactory as the flowers of sulphur.

DRY-MIX SULPHUR-LIME

In recent years self-boiled lime-sulphur has been replaced to a considerable extent by a mixture of finely ground sulphur and lime to which a casein spreader has been added. The materials needed for 50 gallons of spray are as follows:

Finely ground sulphur	pounds	8
Hydrated lime	do	4
Calcium caseinate	pound	½

The ingredients should be thoroughly mixed; the mixture may then be stored in a dry place indefinitely. Lead arsenate may be used with this mixture, although for peach spraying the danger of arsenical injury to foliage and young wood necessitates the use of double the usual quantity of hydrated lime, 8 pounds in 50 gallons instead of 4.

Like self-boiled lime-sulphur, dry-mix sulphur-lime is used primarily as a fungicide, but it has more or less value in preventing the settling of young scales. When temperatures are very high, this material also is partly effective against the European red mite and certain other mites.

DUSTING WITH SULPHUR

Sulphur, in powdered form, is employed for the destruction of the red spider and other mites on plants in foliage. Commercial ground sulphur may be used and, if finely powdered, will be as effective as the more expensive flowers or sublimated sulphur. The sulphur in dry form may be used either pure or diluted with equal parts of a carrier such as hydrated lime, gypsum, flour, etc. When only a few plants or trees are to be treated, a small hand duster, fig. 25, p. 51) is sufficient, though larger apparatus (fig. 26, p. 52) will be needed for orchard work.

PETROLEUM-OIL SPRAYS

Petroleum oils have long been known to possess marked insecticidal properties, but their use in the control of orchard pests has been more or less restricted because of the danger of injury to the plants. In recent years much has been learned about oil sprays and their use, and the extent to which they are employed has been increasing very rapidly.

PETROLEUM-OIL SPRAYS FOR DORMANT USE

LUBRICATING-OIL EMULSIONS

When used in spraying orchard trees, oils are usually diluted with water in order to reduce the oil deposit left on the tree to the quantity needed for effective control. The distribution of the oil in water is accomplished by a process known as emulsification, in which the oil is broken up into extremely fine droplets similar to the globules of butterfat in milk. A third substance, known as the emulsifier, holds the oil globules apart, and prevents their uniting in a separate layer of oil. In general, the oil is first emulsified with an emulsifying agent dissolved in a little water, forming a stock mixture containing from 50 to 90 per cent of oil. This stock emulsion is further diluted in the spray tank at the time of spraying.

Emulsions prepared from certain grades of lubricating oil have been in use in Florida for a number of years for the spraying of citrus trees. Early in 1922 it was found by the Bureau of Entomology that these emulsions, which may be prepared from very cheap lubricating oils, are also remarkably effective at low dilutions for the control of the San Jose scale on dormant deciduous trees. As a result, this type of spray has come into very general use in the dormant control of the San Jose scale and of a few other insect pests in many sections of the country.

The oils which have been found suitable for the dormant spraying of deciduous-fruit trees are the lighter lubricating oils, such as are used in slow-moving bearings, as well as a few of the oils ordinarily used for floor dressings. Such oils have sometimes been referred to as "red engine" oils, but this term is too inclusive to designate accurately the type of oil suitable for the control of insect pests. Certain technical specifications will describe more definitely the type of oil which has been found most satisfactory. The important properties appear to be viscosity [8] and volatility.[9]

The viscosity which an oil should possess to be suitable for dormant spraying seems to vary somewhat in different parts of the country. In the Ozark section of Arkansas, oils having a viscosity of about 200 seconds have been found to have the maximum effectiveness, and such oils are used by most of the growers in that section. Workers in the southeastern part of the United States recommend oils having a viscosity of 125 seconds or more. In the more northern fruit regions, oils having a viscosity of 90 to 100 seconds seem to give as good results as the heavier ones, possibly because the lower temperatures which normally prevail during the dormant season permit the oil to remain longer on the trees.

The volatility should be low; in other words, the oil should be one which will not evaporate too quickly.

Soap-oil emulsions

Probably the most widely known lubricating-oil emulsion is that prepared according to the formula developed by W. W. Yothers of the Bureau of Entomology for use in the control of citrus pests. This was first found effective in the control of the San Jose scale by A. J. Ackerman, also of the Bureau of Entomology.

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[8] Viscosity is specified technically in seconds, the length of time it takes a given quantity of oil to pass through a given opening under standard conditions. (Tested by Saybolt universal viscosimeter.)

[9] Volatility indicates the percentage of the oil which evaporates under certain standard conditions in a specified time.

This formula utilizes soap as the emulsifier, and heat is necessary for the preparation of the emulsion. It is made up as follows:

Oil	gallon	1
Potash fish-oil soap	pound	1
Water	gallon	½

The soap ordinarily used is a liquid potash fish-oil soap containing 30 per cent or more of soap by weight. Potash soap is more satisfactory than soda soap, because it does not become hard on cooling. The water used should be soft if possible.

The ingredients are mixed together, the whole brought to a boil, and then, while still hot, pumped at least twice through a small opening, such as that in a spray gun or a very coarse disk nozzle. The emulsion should be pumped from one container into another, so that all of the material will pass through the pump. A bucket pump (fig. 17), vigorously used, will give a good emulsion, although for making large quantities a power-driven pump is of course desirable. The emulsions made with the larger pumps are usually more stable than those made with a bucket pump and will keep for longer periods of time, since the greater pressure breaks the oil up into finer droplets. Hot oil is very destructive to fiber or rubber pump packing, and if large quantities of emulsion are to be prepared, metal packing should be used. Various sources of heat have been successfully employed. Some manufacturers use a steam-jacketed copper kettle, while others use live steam introduced into the mixture through a coil in the bottom of the cooking vat.

This formula results in a stock containing approximately 66 per cent of oil by volume, some allowance for the manner of manufacture being necessary. If the stock is cooked in a shallow container over an open fire, excessive evaporation may unduly reduce the volume of water and thus increase the proportion of oil. The use of live steam causes a slight increase in the quantity of water present. The pumping sometimes incorporates more or less air into the mixture, but the emulsion usually shrinks to normal volume on standing and cooling.

Another emulsion, the resin-fish-oil-soap emulsion, is prepared without the use of heat, and is made up as follows: Lubricating oil, 9 gallons (about 65 pounds), resin potash fish-oil soap, 1 gallon (about 8 pounds).

Pour the soap into a suitable container, then add a quantity of oil not to exceed one-third of the volume of the soap. Stir rapidly until all the oil has disappeared into the soap, and the mixture has become somewhat stiff. Continue to add successively larger quantities of the oil (each additional quantity of oil never to exceed one-third of the total bulk of the mixture already made). Stir in thoroughly each addition of oil and do not add more until a stiff jellylike consistency is obtained. This procedure should be continued until the required quantity of oil has been emulsified. This emulsion may be made in a small way with a bucket and paddle, but for quantity production a power mixer is desirable. (Fig. 4.)

The stock emulsion made according to this formula contains approximately 90 per cent of oil by volume. It should be stored in air-tight containers. Any free oil found on the surface after the mixture has been standing may be stirred in again without difficulty. The resin-fish-oil-soap emulsion is very resistant to the action of hard waters, which is a decided advantage in many localities.

Ordinary potash fish-oil soap may also be used in this formula when soft water is to be used in diluting the emulsion.

In dealing with any oil spray, the grower should keep in mind the fact that most mixtures of oil in water are temporary in nature and that the oil tends to separate into a distinct layer, which does not readily mix again with the water. This separation of oil, or breaking of the emulsion, renders the spray unsuitable for use, since the greater part of the liquid in the tank then contains insufficient oil for proper effectiveness, whereas the remainder of the mixture contains such a great proportion of oil that injury to the trees may result.

The complete separation of the oil just described should not be confused with "layering," or "creaming," which occurs with many diluted oil sprays. Layering is analogous to the rising of cream on milk, the cream in this case consisting of the globules of oil, accompanied by the emulsifier and any other solid or semisolid materials which may be present. While creaming often results in apparently distinct layers of materials, a moderate amount of stirring or agitation restores the entire mixture to its original uniform condition.

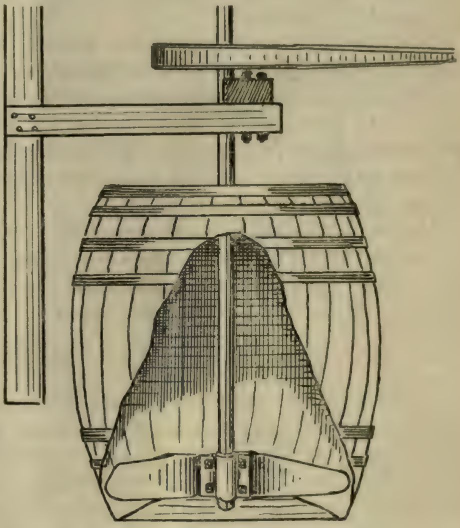

FIGURE 4. Outfit suitable for preparing oil emulsions with resin fish-oil soap by the cold-stirred process

Use of soap-oil emulsions with hard waters.—When a soap-oil emulsion is diluted with hard water the soap is often rendered useless as an emulsifier; the oil is liberated and rises to the surface in the spray tank. If the water is only slightly hard, the use of a little additional soap in the preparation of the emulsion will often overcome the difficulty. The emulsions prepared with resin fish-oil soap are much more resistant to the action of hard water than those made according to the standard formula, and so may be used successfully in most limestone sections.

One means of overcoming difficulty with hard water, which has proved successful in many eastern and middle-western fruit districts, is by using a weak Bordeaux mixture (½–½–50) for diluting the emulsion. When the soap is eliminated by the action of the hard water, the Bordeaux acts as a substitute emulsifier and maintains the emulsion. The resulting mixture layers rather rapidly, however, and a moderate amount of agitation is needed to insure a uniform emulsion. The agitation provided by present-day sprayers is adequate for this purpose.

A residue of lime-sulphur in the spray tank will sometimes cause an oil emulsion to break down in a manner similar to that which occurs with hard water. All such foreign matter should be washed out of the spray tank before the use of a soap-oil emulsion is attempted.

Storage of soap-oil emulsions.—A well-made soap-oil stock emulsion is stable for a fairly long period, and no difficulty is likely to be experienced if the requirements for an entire dormant season are stored from fall until spring. A gradual separation takes place, however, and stock emulsions carried over from one year to the next are often in poor condition the second season.

Stock emulsions should be stored in clean containers. Old lime-sulphur barrels should not be used for storing soap-oil emulsions, since it is almost impossible to remove the lime-sulphur so completely that the emulsion will not be broken down by the action of the calcium salts present.

The boiled stock emulsion should be protected from temperatures much below freezing. Frozen emulsions sometimes break down, especially if they are moved about while still frozen. If allowed to thaw out gradually without being disturbed, however, they are seldom seriously damaged. The cold-stirred soap-oil emulsions do not freeze very readily and may be safely stored at temperatures nearly down to zero.

Boiled lubricating-oil emulsion which has been stored for long periods should be thoroughly stirred before any material is drawn off, since the excess water and soap present tend to settle to the bottom, forming a separate layer.

Cold-mixed emulsions

Certain other materials may be used as emulsifiers, and oil sprays prepared with these materials have some advantages not possessed by those in which soap is used, chiefly that of mixing readily with hard waters. Two of these emulsions were first suggested in this country by workers at the Missouri Agricultural Experiment Station and are sometimes referred to as "Missouri cold-mixed emulsions." As the name implies, no heat is required in their preparation. One of these formulas, using a casein-lime spreader as an emulsifier, is as follows:

Oil	gallon	1
Calcium caseinate	ounces	2
Water	gallon	½

Work the calcium caseinate with some of the water into a thin paste free from lumps, add the remainder of the water and then the oil, and pump several times from one container into another through a small opening such as that in an ordinary spray gun. The preparation of satisfactory cold-mixed emulsions requires greater pressures than are needed in making the boiled soap-oil emulsion. An ordinary bucket pump is often inadequate for this purpose, and much better emulsions may be made with a power-driven pump.

The calcium caseinate should be fresh, since material which has been on hand for long periods is often unsuitable for use as an emulsifier. The stock emulsion prepared according to this formula should be used within a day or two from the time it is made up; if stored for longer periods the oil often separates, making it impossible to obtain a uniform diluted emulsion. Some growers use a power sprayer for preparing cold-mixed emulsions, either mixing at one time the requirements for a short period or making only enough for each tank load as needed. In preparing large quantities the material is mixed in the spray tank, pumped into barrels or other containers, and then pumped back and forth until emulsification is complete. For this purpose an overhead suction hose is convenient. In making only enough for a tank load at a time, the quantity of material is usually small enough for a good emulsion to be made by merely pumping it through the spray nozzle back into itself for a few minutes before filling the tank with water.

The calcium caseinate-oil emulsions are usually unaffected by hard waters, although in New Mexico it has been found that waters containing large quantities of magnesium salts break down this type of emulsion.

A freshly made Bordeaux, consisting of 2 ounces of copper sulphate, 3 ounces of hydrated lime, and one-half gallon of water for each gallon of oil, may be similarly used for the preparation of a cold-mixed emulsion.

A number of proprietary cold-mixed emulsions have made their appearance on the market, and for the most part these products have given very satisfactory results. Most of them are in the form of a thick paste, containing from 75 to 85 per cent of oil. They should be used at the concentrations recommended on the label by the manufacturer.

Dilution of lubricating-oil emulsions

The dilutions recommended for lubricating-oil emulsions are usually expressed as percentages of oil, and refer to the content of actual oil, rather than to the proportion of stock used. The recommendations assume that the stock contains some standard proportion of oil—usually 66⅔ per cent. On this basis, to obtain 100 gallons of a 2 per cent diluted spray 3 gallons of stock will be required; 3 per cent of oil requires 4½ gallons; 4 per cent requires 6 gallons. If the stock material contains more or less oil than the 66⅔ per cent in the standard formula, the proper quantity of stock to use may be ascertained from Table 2.

TABLE 2.—*Dilutions of lubricating-oil stock emulsions of different oil content for obtaining various strengths of spray*

Oil content of stock material	Quantity [1] of stock needed to obtain 100 gallons of spray material having an oil content of—			
	1 per cent	2 per cent	3 per cent	4 per cent
	Gallons	*Gallons*	*Gallons*	*Gallons*
50 per cent	2	4	6	8
55 per cent	2	3¾	5½	7½
60 per cent	1¾	3½	5	6¾
65 per cent	1¾	3¼	4¾	6¼
66⅔ per cent	1½	3	4½	6
70 per cent	1½	3	4½	5¾
75 per cent	1½	2¾	4	5½
80 per cent	1¼	2½	3¾	5
85 per cent	1¼	2½	3¾	4¾
90 per cent	1¼	2¼	3½	4½

[1] Fractions are rounded off in each case to next higher quarter gallon.

KEROSENE EMULSION

Kerosene emulsion was one of the earliest of the petroleum-oil sprays and still is occasionally used. A stock emulsion containing 66 per cent of kerosene may be made by substituting kerosene for lubricating oil in the preparation of the formula on page 18. If the emulsion is cooked over an open fire the kerosene should not be added until the boiling soap solution has been removed from the fire, since kerosene is much more inflammable than the heavier lubricating oil. Kerosene emulsion is used at from 20 to 25 per cent of oil for dormant spraying and at about 10 per cent strength for foliage spraying. It has been largely replaced by the lubricating-oil emulsions and miscible oils for dormant work, and by the nicotine preparations for summer spraying.

DISTILLATE-OIL AND CRUDE-PETROLEUM EMULSIONS

Emulsions may also be prepared from distillate oils and from crude petroleum by following formulas very similar to those already indicated for lubricating oil. While formerly much used, such sprays have very largely given way to the lubricating-oil emulsions and the miscible oils.

MISCIBLE OILS

Miscible oils are also in very common use in dormant spraying. A stock miscible oil is clear and similar in appearance to ordinary lubricating oil. It has the emulsifier dissolved in it, but the oil is not broken up into droplets until water is added.

A number of reliable and effective proprietary miscible oils are available on the market. These oils differ greatly in composition, and no specific directions will be given here for their use, since recommendations as to their dilution and use will be found on the labels.

Miscible oils have certain advantages over the emulsions; they are very convenient to use, the mixing operations do not require such close supervision as is necessary with the emulsions, they cause little difficulty with hard waters, they may be stored indefinitely, and do not freeze readily.

The relative covering powers of the miscible oils and the lubricating-oil emulsions appear to be approximately equal, according to tests conducted by the Bureau of Entomology.

OIL SPRAYS FOR SUMMER USE

The oil sprays in common use for dormant spraying, when employed at effective strengths, are unsafe for use on trees in foliage; although in emergency cases certain emulsions of ordinary lubricating oil have been used on apple (but not on peach) with comparatively little injury. In recent years it has been found that highly refined oils of the type used for medicinal purposes, and often referred to as " white " or " crystal " oils, may be used during the growing season with less danger of injury. These summer oils are available chiefly in the form of cold-mixed emulsions of the paste type.

Under the pressure of the spray-residue problem, the white oils have been used quite extensively in an experimental way against the codling moth, especially in the Northwest. The results of these experiments indicate that the summer oils may have a place in the apple-spray program, especially in combination with nicotine, for the control of the second and later broods of the codling moth. In some districts this may enable the growers to avoid the necessity for washing their fruit to remove excess arsenical residue. In the Northwest, however, it merely serves to reduce the quantity of residue to the point where it may more readily be removed by washing. The addition of the summer oils to lead arsenate also seems to result in a more effective spray than either material alone; but the use of this combination must be restricted to the early part of the season, for if used throughout the season serious difficulty may be encountered in the removal of the spray residue at harvest time.

The oils which have proved most satisfactory are considerably lighter than those used for dormant spraying, ranging in viscosity from 55 to 75 seconds. The degree of refinement (technically termed "the unsulphonated residue") ranges from 85 to 100 per cent.

Most of the work with summer oil sprays has been done on apple, which seems to be much more resistant to oil injury than peach. The use of an oil spray in combination with, or shortly after, the application of a sulphur fungicide is very likely to result in serious injury to the foliage, a factor which tends to limit the use of oils in localities in which sulphur fungicides are needed throughout the greater part of the season. At present the investigators in the Northwest recommend that not more than three applications of oil be made in one season. Much further experimental work with oils on all kinds of fruit trees will be needed before their exact place in the summer spray program will be established.

SOAP SPRAYS

Soaps are not only extensively used for making oil emulsions, but solutions of various kinds of soap are often used for the destruction of soft-bodied sucking insects, particularly aphids, the pear psylla, certain plant bugs, etc., and soaps are also frequently combined with other spray materials to cause them to spread and adhere to the foliage better.

FISH-OIL SOAPS

The commercial fish-oil soap, formerly known under the trade name of "whale-oil soap," is usually made from fish oils combined with either caustic soda or potash and contains varying proportions of water. An average grade of a soda fish-oil soap should contain, in addition to 30 per cent of water, about 10 per cent of caustic soda, 58 per cent of fatty matter as anhydrides, and about 2 per cent of other matter. Soda fish-oil soap is generally of medium to hard consistency and should be sliced to facilitate its being dissolved in hot water. It is brownish in color, with a distinct fishy odor. The potash fish-oil soap, much used as an emulsifier in the preparation of oil sprays, is a thick liquid containing from 60 to 70 per cent of water, and only from 30 to 40 per cent of soap. This material flows rather freely and is very convenient to handle.

For foliage sprays 1 pound of fish-oil soap is dissolved in 3 or 4 gallons of water, or at greater dilutions, depending upon the insects to be treated, the hardiness of the foliage, the proportion of actual soap in the product, and the hardness of the water which must be used in diluting the spray. This last factor is of considerable importance in many fruit districts. Soft water should be used if possible when spraying with soap, since hard water destroys the insecticidal value of a portion of the soap. In case the only available water is hard, the proportion of soap must be increased, the exact increase varying with the degree of hardness of the water. For the dormant treatment of scale insects 2 pounds for each gallon of water is used and it should be applied while hot. Soda soaps, especially when used in this proportion, are likely to solidify upon cooling and clog the spraying apparatus.

Fish-oil soaps may be used with the following spray materials to increase their spreading and adhesive qualities: Lead arsenate, nicotine solutions, Bordeaux mixture, and sulphur. Soap should not be used in lime-sulphur solutions, or in waters strongly alkaline.

TOBACCO FISH-OIL SOAP

Commercial fish-oil soaps containing small percentages of nicotine are sometimes sold for insecticidal purposes. Soaps of this kind are somewhat expensive, and their use is scarcely justified unless the nicotine is present in sufficient quantity to have distinct insecticidal value, namely, from 0.05 to 0.06 per cent in the completed spray.

RESIN FISH-OIL SOAP

Commercial resin (rosin) fish-oil soaps are often used in the proportion of from 2 to 3 pounds to 50 gallons of spray to increase the adhesiveness of the spray material, especially on plums, grapes, and cranberries. They may be employed with lead arsenate, Bordeaux mixture, and nicotine solutions with satisfactory results. When applied alone as a soap spray, they should be used at about the same strength as fish-oil soaps. Resin potash fish-oil soap has also been found useful in preparing the cold-stirred soap-oil emulsion. (See p. 18.) The resulting product has the advantage of being quite stable in hard water.

HOUSEHOLD SOAP

In the absence of fish-oil soaps, ordinary soap often may be used effectively where only a few plants are to be treated. An average soap should be employed on plants in foliage in the proportion of 1 pound to from 2 to 4 gallons of water, according to the kind of soap and the insects to be treated.

TOBACCO OR NICOTINE INSECTICIDES

Nicotine in solution, obtained from tobacco, has long been recognized as an effective agent for the destruction of many soft-bodied sucking insects, particularly aphids, pear and other thrips, pear psylla, etc. Nicotine solutions are especially valuable as contact sprays, since they can be applied at the required insecticidal strength without injury to the foliage. Moreover, nicotine extracts may be combined with many of the standard stomach poisons and fungicides without depreciating their value. These combination sprays are much used when it is desired to treat at one time certain sucking and biting insects and fungous diseases.

Commercial nicotine, extracted from refuse tobacco, is sold on the market in several grades and strengths. A highly concentrated preparation, containing 40 per cent of nicotine, is at present being used extensively. The diluted spray material should contain not less than 0.05 or 0.06 per cent of nicotine, and in orchard spraying nicotine sulphate (40 per cent nicotine) is used in the proportion of about three-fourths of a pint to 100 gallons of spray. For small spraying operations use about three-fourths teaspoonful to a gallon, or 1 fluid ounce to 8 gallons, of soapy water. (See dilution table, p. 61.)

Soap should always be used with nicotine sulphate unless it is already combined with some other alkaline material, such as Bordeaux mixture or lime-sulphur. Some investigators have found that, in addition to causing the spray to spread and adhere better, the soap or the fungicide liberates free nicotine, thus making the spray more effective.

TOBACCO DUST

Tobacco dust has long been recommended for the control of the woolly apple aphid (*Eriosoma lanigerum* Hausm.) on the roots of the apple and for other root-inhabiting insects, and to a less extent for dusting low-growing plants, such as currants and gooseberries, for the destruction of aphids.

The effectiveness of tobacco dust as a treatment for the woolly aphid on the roots of the apple varies with the amount of nicotine in the dust and its fineness and the character of the weather. Abundant moisture in the soil, as from irrigation or rains, leaches out the nicotine, which then destroys the insects to a greater or less extent. Where tobacco dust may be obtained cheaply its use is warranted for the woolly aphid, but the purchaser should assure himself that the dust is not the grade sold for fertilizer purposes from which the nicotine has been extracted. In addition to its insecticidal value, tobacco dust has a considerable fertilizer value.

Nicotine is sometimes also applied in a dust carrier, the dust being prepared by thoroughly mixing nicotine sulphate (40 per cent nicotine) solution with about twenty times it weight of hydrated lime. A homemade mixer for preparing nicotine dust is shown in Figure 5, taken from Farmers' Bulletin 1499,[10] The Melon Aphid and Its Control, to which the reader is referred for more complete instructions on the preparation of nicotine dusts.

To have maximum effectiveness, nicotine dust should be used when the temperature is above 70° F., at a time when the foliage is dry, and when there is a minimum of air movement. Since the operation is essentially an open-air fumigation, and most of the killing is done by the liberated nicotine in the form of a vapor, even a slight movement of air will carry the vapor away before it has time to affect the insect. Because of the difficulty experienced in finding air conditions satisfactory for their application, nicotine dusts have never come into very general use in the control of orchard insects, although on low-growing crops they have proved quite successful.

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[10] The bulletin may be obtained free upon application to the U. S. Department of Agriculture.

DERRIS EXTRACTS

Extracts of the roots of Derris, a tropical plant used by the natives of the East Indies as a fish poison, are used to some extent as contact poisons against many soft-bodied insects and are fairly effective for this purpose. These extracts are available chiefly as proprietary materials, which are of such strength that they should be diluted on much the same basis as are the commercial nicotine extracts. The active principles in Derris are practically nonvolatile and do not cause the discomfort sometimes experienced by spray men in applying nicotine.

PYRETHRUM EXTRACTS

Pyrethrum (*Pyrethrum cinerariaefolium* Trev. and closely related species) has long been known to possess insecticidal qualities, and the pulverized dried flower heads have for many years formed the basis of certain insect powders. In recent years, more or less standardized extracts of pyrethrum have been used as household sprays against flies and other insects. A number of proprietary extracts prepared for the spraying of plants are now on the market, and these possess considerable value as contact materials against soft-bodied insects. The various brands differ greatly in the method of extraction and preparation of the pyrethrum, as well as in the proportions of the active ingredients present. The directions given on the label of the container should be followed as to the strength to use for different insects.

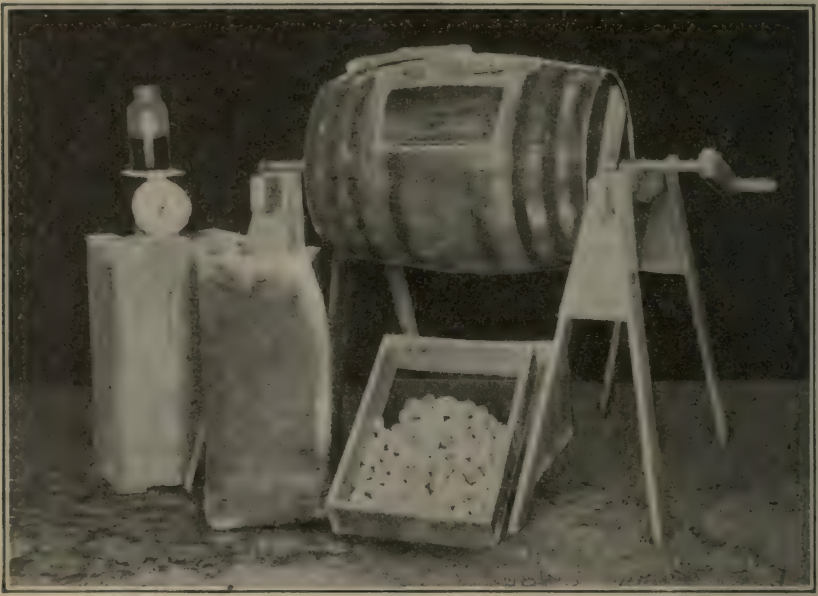

FIGURE 5.—Homemade ball mill for mixing nicotine dust

OTHER MATERIALS USED IN SPRAYING

Several other materials, which can not be classed exactly with either the stomach poisons or the contact materials, are often used in spraying for the control of insect pests, either for their direct insecticidal value, or in conjunction with insecticides.

BORDEAUX MIXTURE

Although essentially a fungicide, Bordeaux mixture is sometimes recommended as a repellent to insects and is said to have considerable value in the control of certain leaf hoppers. One formula for making Bordeaux in quantities of 50 gallons and 5 gallons is inserted here, since this material is several times referred to in the spraying schedules for apple and grape for the combined treatment of diseases and insects.

50-gallon lots

Copper sulphate (bluestone)	pounds	4
Fresh stone lime	do	4
(Or hydrated lime)	do	6

5-gallon lots

Copper sulphate (bluestone)	pound	½
Fresh stone lime	do	½
(Or hydrated lime)	do	¾

A Bordeaux of this strength is referred to as a 4–4–50 mixture, the first figure referring to the number of pounds of copper sulphate, the second to the number of pounds of stone lime, and the third to the number of gallons of water.

DIRECTIONS FOR MAKING

A stock solution of bluestone is made by dissolving it in the proportion of 1 pound to 1 gallon of water. The bluestone should be suspended in a cloth sack in a barrel, or other nonmetal container, so that it is just beneath the surface of the water. The crystals will be dissolved if left for a few hours in cold water and in a shorter time in hot water. A stock milk of lime may be made by slaking the lime in a little water and then further diluting it so that each gallon contains 1 pound of lime. If hydrated lime is used, it should be worked into a thin paste and diluted in a similar manner. Just before the stock solutions are used they should be stirred thoroughly.

Bordeaux mixture was formerly made by diluting each ingredient with about half the total volume of water to be used and then running the two simultaneously into the spray tank, a method which necessitated rather extensive mixing apparatus, with elevated tanks and platform. For mixing small amounts this method is very convenient. At present most of the mixing of Bordeaux is done directly in the spray tank. It seems essential, however, to have one or the other of the ingredients in a dilute form before the two come into contact with each other. One mixing method in common use is to fill the tank from two-thirds to three-fourths full of water, add the copper sulphate solution (with the agitator running), then the milk of lime, and, finally, complete the filling of the tank with water. Recently there has appeared on the market a finely pulverized copper sulphate that goes into solution very rapidly. This may be dissolved by washing it through the screen (which should be of copper or brass) while the tank is being filled. By the time the tank is nearly full the bluestone will be completely dissolved, and the lime may then be added as previously described. Bordeaux mixture deteriorates on standing and should therefore be used as soon as possible after it is mixed.

For early summer spraying the quantity of bluestone may be reduced to 3 pounds, or even less, to reduce the danger of russeting the fruit. Bordeaux mixture for grape spraying is made up of 4 pounds of bluestone and 3 pounds of stone lime in 50 gallons of water.

Prepared Bordeaux mixtures are on the market, both in the form of a paste, and in dry, powdered form.

LIME

In addition to being an essential ingredient of Bordeaux mixture, lime finds many other uses in the insect-control program. It is used as a corrective with arsenicals to combine with any soluble arsenic which may be present, or which might be liberated. In peach spraying the addition of lime to lead arsenate is absolutely necessary to reduce foliage injury, and in many sections lime is similarly used in apple spraying. Usually from 2 to 4 pounds of hydrated lime or the equivalent in stone lime are used with each pound of lead arsenate.

Hydrated lime is a well-known commercial product made by slaking stone lime with water. The excess water is then evaporated, leaving dry hydrated lime. This should not be confused with air-slaked lime. For many purposes either stone lime or hydrated lime may be used, three-fourths of a pound of stone lime being equivalent to 1 pound of hydrated lime.

In the process of manufacturing hydrated lime, three grades are produced. The coarsest is known as agricultural hydrated lime, the medium grade as mason's hydrated lime, or finishing lime, and the finest as chemical hydrated lime. The medium grade is more readily available but contains considerable quantities of grit, which causes excessive wear to spray pumps and nozzles. The finest grade, or chemical hydrated lime, costs a little more but is more satisfactory for spraying purposes if it can be obtained.

Hydrated lime is much used as a filler in the preparation of dusting materials, being added to increase the bulk of the dust, and thus reduce the strength of the active and more expensive ingredients, as well as to reduce the danger of foliage injury when arsenicals are used.

Hydrated lime has also been found recently to have a certain direct value in insect control, acting as a barrier and deterrent to newly hatched oriental fruit-moth larvae. The quantity required to give an appreciable degree of control is so great, and the application is of necessity so late, that an unsightly (though nonpoisonous) residue may be present on the harvested fruit. This residue, together with the resulting poorer color of the fruit, materially lessens its market value.

SPREADERS AND STICKERS

A great many materials have been recommended from time to time for use in spray mixtures for the purpose of causing the spray to spread better over the foliage and fruit, or to improve its sticking qualities, or both. The various soaps are used with many spray mixtures for this purpose. Soaps sometimes cause difficulty by foaming and frothing, thus keeping the pump from maintaining the proper pressure. Soaps are incompatible with certain sprays, especially with lime sulphur, and are also to a considerable extent wasted when used with very hard waters.

CASEIN-AND-LIME SPREADERS

The spreader in most common use is a mixture of casein and lime, often referred to as calcium caseinate. Several of these spreaders have been widely advertised, and rather broad claims have been made for them. The available experimental evidence, however, seems to indicate that the indiscriminate use of calcium caseinate in all spray applications is not worth while, and under some conditions may even be undesirable. This material, however, has several important uses in orchard spraying. It serves as an emulsifier for oil sprays (p. 20), and is used in the preparation of dry-mix sulphur lime (p. 16).

Calcium caseinate should not be stored over too long periods, especially if exposed to the air. If so exposed the hydrated lime in it gradually becomes air-slaked, and the mixture loses much of its value.

FISH OIL

Fish oil has been found by Hood [11] to be a very effective sticker for lead arsenate, and several other workers have reported favorably on the use of this material for the spraying of apples and grapes. The recommendations call for 3 fluid ounces (a little less than a half cup) for each pound of insecticide. The fish oil is merely poured into the spray tank when it is nearly full, and in a power outfit is emulsified by the action of the agitator. With smaller spray outfits it is sometimes necessary to pump the liquid back into itself a few minutes to mix in the fish oil. In buying fish oil for use in orchard spraying, the fruit grower should specify a "choice, light-pressed menhaden oil" having less than 5 per cent of free fatty acid. Linseed oil may be used for the same purpose and is more pleasant to handle, but is more expensive.

The use of fish oil should be restricted to the early part of the season, since, if applied with lead arsenate late in the season, it may cause excessive spray residue at harvest time.

FUMIGANTS

FUMIGATION OF NURSERY STOCK

Fumigation of trees from the nursery before planting, and of buds, grafts, etc., for the destruction of scale insects, aphids, and other nursery pests is practiced by some orchardists and nurserymen.

FUMIGATION BOXES

When large quantities of nursery material are to be fumigated, as by nurserymen, specially constructed fumigation houses are used, but fumigation boxes of various sizes are employed for smaller operations, as by orchardists. These boxes, of any convenient size, as 6 feet long, 3 feet high, and 3 feet wide, may be made of two thicknesses of lumber, such as plain matched ¾-inch ceiling, flooring boards, double-matched sheathing, etc. Between the two layers of boards should be placed a double thickness of tarred paper. Near the bottom of the box should be placed a few cross pieces or slats, on which to lay the nursery material, sufficient space beneath being allowed for the generator. The box should be strongly reinforced at the corners and at other necessary places, and on one side of the box, at the bottom, a small door or opening which can be tightly closed should be provided for the admission of the generating receptacle and chemicals. The top or lid should be fitted to close very tightly against a felt weather strip. In place of a complete fumigation box some growers use a box without a top, inverted bottom upward on the ground, the earth being packed tightly around the edges to prevent the escape of the gas. Whatever may be the type of box, it must be as nearly air-tight as possible and kept in that condition by necessary repairs. It will be well to give the box two coats of paint inside and out each year.

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[11] U. S. Department of Agriculture Technical Bulletin 111, Fish Oil as an Adhesive in Lead-Arsenate Sprays. 28 p., illus. 1929.

The most effective fumigant is hydrocyanic acid gas. This is extremely poisonous and if inhaled may prove fatal. Preferably it should be used by experienced operators and every precaution taken not to breathe any of the gas. Great care should also be taken to keep all chemicals accessible only to those using them, as the cyanides are very poisonous and the sulphuric acid extremely caustic.

Hydrocyanic acid gas, if properly used, will not injure well-matured dormant nursery stock, neither will immature material, as buds, be damaged by effective quantities of the gas. The material to be fumigated should be reasonably dry and separated somewhat so that the gas may surround it thoroughly.

CYANIDE FUMIGATION BY POT METHOD

SUPPLIES

For cyanide fumigation by the pot method the following supplies are required, and the chemicals should be of the grade given below:

Sodium cyanide (96 to 98 per cent), containing 51 to 52 per cent of cyanogen. When purchasing cyanide for fumigation purposes, this grade, which is known as fumigation cyanide, should always be specified.

Sulphuric acid. This should be a high-grade commercial product testing about 66° Baumé (1.84 specific gravity).

Generating vessel. An earthen crock, china dish, or bowl may be used as a receptacle for the water and acid. Do not use a tin or iron vessel of any kind, as the acid will corrode these metals.

FORMULAS

The formula to be used will depend upon the character of material to be fumigated, dormant trees and grafts being given a heavier dosage than buds.

Formula for dormant trees and grafts

Sodium cyanide	ounce	1
Sulphuric acid	fluid ounces	1½
Water	do	2

Formula for buds

Sodium cyanide	ounce	½
Sulphuric acid	fluid ounce	¾
Water	do	1

Either of the above formulas produces the proper volume of gas for 100 cubic feet of inclosed space. The quantities of ingredients should be decreased or increased in proportion for smaller or larger boxes. A box of the size mentioned on page 30 would require about one-half these quantities of materials.

PROCESS OF FUMIGATION

After the material to be fumigated has been placed in the house or box, and everything is in readiness, put the generator jar or jars in place with the necessary water. Then pour the acid very slowly into the water. Never pour the water into the acid, as this procedure causes considerable spattering of the acid. Next weigh out the cyanide and place it in a small paper sack and then gently drop it into the generator. The operator must close the box or leave the house at once. Where several generators are to be used, as in a large fumatorium, the sacks of cyanide should be lowered into the generating vessels by means of strings operated at the door. By taking this precaution the operator will avoid any possibility of inhaling the deadly gas. The material should be fumigated for a period of from 45 minutes to 1 hour.

In fumigating houses or large chambers, facilities for opening the doors and windows from the outside must be provided so as not to expose the operator to the fumes. No one should enter the fumatorium until all the gas has been liberated by thorough ventilation.

CALCIUM CYANIDE FUMIGATION

The fumigation method outlined above, requiring the use of sodium cyanide and sulphuric acid, has been replaced to some extent by the use of calcium cyanide, a compound which liberates hydrocyanic acid gas when it comes into contact with the moisture in the air. Calcium cyanide is available in several forms, the most satisfactory of which is a fine dust. This material is merely blown or sprinkled over the floor of the fumigating chamber which is then tightly closed for a period of several hours. Judging by recent work from one-half to 1 ounce for every 100 cubic feet of space to be fumigated is ample. The humidity must not be too low or there will not be enough moisture in the air to liberate all of the gas. In case the fumigation chamber is very dry, some moisture should be provided by sprinkling the walls with water, or by adding masses of moistened newspapers. The quantity of water supplied, however, should not be so great that actual drops of moisture are present at the time of fumigation.

Calcium cyanide dust has also been used in an experimental way as an open-air fumigant in the control of such sucking insects on deciduous fruits as the grape leaf hopper (*Erythroneura comes* Say), pear psylla (*Psyllia pyricola* Först.), and apple leaf hopper (*Empoasca mali* LeB.). While considerable numbers of the insects may be killed under ideal conditions, this method of control has never come into practical commercial use. Dusting with calcium cyanide is subject to the same requirements as apply to the use of nicotine dust on deciduous-fruit trees (p. 25), except that high temperatures are not so essential to effective work.

PARADICHLOROBENZENE

Paradichlorobenzene, first tested as a soil fumigant by E. B. Blakeslee, of the Bureau of Entomology, is now in very extensive use in the control of the peach borer (*Synanthedon exitiosa* Say), and of a few other species. Paradichlorobenzene is a white crystalline material, somewhat similar in general appearance to granulated sugar. This chemical gradually vaporizes, the odor of the vapor being somewhat like that of naphthalene. At 77° F. the mixture of paradichlorobenzene vapor and air is about one-half of 1 per cent heavier than air. The gas is toxic to insects, although its action is very much slower than that of hydrocyanic acid gas. Paradichlorobenzene should be about the fineness of granulated sugar, since the coarser grades vaporize too slowly for best results. Paradichlorobenzene should be stored in air-tight containers to avoid loss by evaporation.

Only unadulterated paradichlorobenzene should be bought, for if a filler has been added the actual strength of the material is further reduced to an unknown extent if any of the active ingredient evaporates before the chemical is applied. The composition of such material is thus uncertain, and if it has been exposed over a long period of time, the mixture may consist chiefly of valueless inert filler.

Directions for the use of paradichlorobenzene are given in a later section of this bulletin (pp. 77–78).

DIPPING NURSERY STOCK

Some nurserymen and fruit growers dip nursery stock, scions, and bud sticks in order to insure as much as possible the destruction of any insects which may be present. The treatment is especially aimed at the San Jose and other scale insects and the woolly apple aphid on apple. The principal dips are: Lime-sulphur concentrate (33° Baumé), 1 part to 7 parts of water (at temperatures of 60° to 120° F.); 2 to 4 per cent lubricating-oil emulsion; or the miscible oils, 1 part diluted with 10 to 15 parts of water. The dipping method is not so effective as fumigation with hydrocyanic acid gas (p. 29) and, further, may cause injury, depending upon the maturity and hardiness of the plants treated. The roots of nursery trees can not be dipped with safety in the lime-sulphur solution. Entire trees, however, may be immersed in the oil emulsions with less danger of injurious results.

WORMING FRUIT TREES

A very effective method of reducing injury to fruit trees by certain borers, as the peach and apple tree borers, is to "worm" the trees regularly in the spring and fall of each year. (Fig. 6.) Previous to worming, the earth should be removed from around the crown of the tree to a depth of 4 or 5 inches and the trunk brushed or scraped free of bark and loose dirt. With a little experience the worker can readily locate the borers in their burrows and remove them by means of a knife, stiff wire, or other suitable tool.

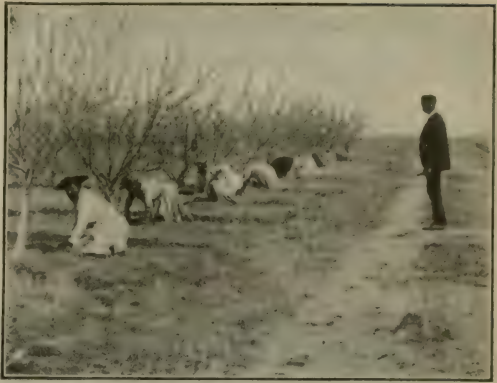

FIGURE 6.—Large-scale worming of peach trees in a Georgia orchard. Except on young trees, this method of controlling peach borers has been largely replaced by the use of paradichlorobenzene

A combined scraping and gouging instrument is used in the South and is reported to be a valuable tool in worming. A piece of steel bar is flattened out along about two-thirds of its length into a dull blade 2 or 3 inches wide and gradually tapered to a point. The point is bent out and slightly upward to form a hook for gouging the insects in their burrows. The other end of the blade is fastened firmly into a 12 or 14 inch piece of wood for a handle, as a section cut from an old hoe or shovel handle. The whole tool is not more than 17 or 20 inches long. Figure 7 shows the tools which are suggested for use in digging out roundheaded apple-tree borers.

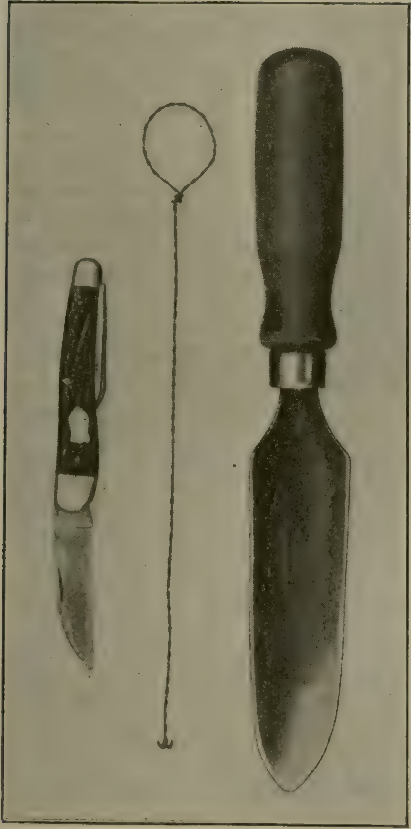

FIGURE 7.—Tools suitable for use in removing roundheaded apple-tree borers from their burrows

In worming, care should be taken not to cut the sound bark or wood more than necessary, and the cutting should be done vertically. Carelessness in the use of worming tools may result in more damage to the trees than would be caused by the insects. After the trees have been wormed it is desirable, if practicable, to go over them again a few days later, when the location of any larvae missed during the first examination will usually be indicated by the exuded frass. After the worming has been completed the earth should be replaced around the trees, and in the case of spring worming of peach trees it should be mounded around the base of the trunk to a height of 8 to 10 inches. (Fig. 8.)

This will cause the borers to enter the bark somewhat higher and facilitate their detection and removal. If washes or wrappings are used, they should be put on at once after the spring worming and before the earth is replaced around the trees. Failure to replace the earth around peach trees after a late fall worming is often followed by severe winter injury to the collar of the tree.

PROTECTIVE AND CAUSTIC WASHES FOR BORERS

Washes of various materials have been recommended for use on fruit trees to repel adult insects that would deposit eggs or to prevent the entrance into the bark of newly hatched larvae. These washes are to be applied after the spring worming and before the adult insects have issued and begun to deposit eggs. Certain caustic washes have also been recommended for use at the time of fall worming to destroy by contact any of the young larvae that may have escaped the hooking and worming methods. As has been stated, reliance for borer control should be placed on worming, or, in the case of peach trees, on the use of paradichlorobenzene, washes being used merely as an adjunct.

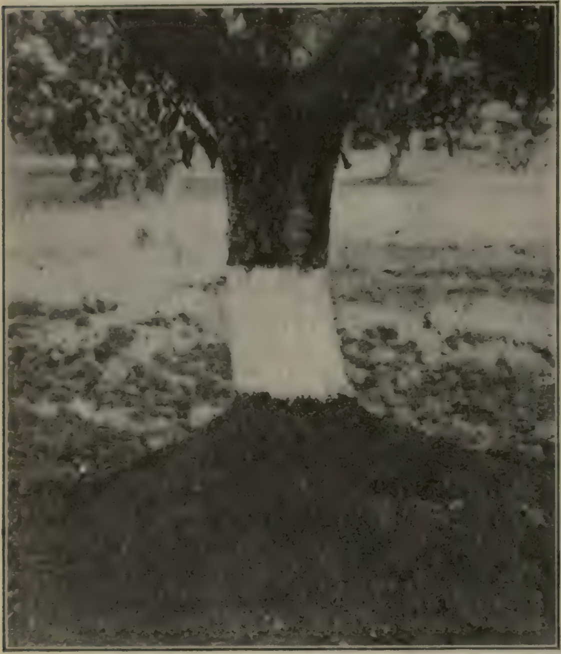

FIGURE 8.—Application of whitewash and mounding of earth around peach-tree trunk against peach borer. Mostly superseded by the use of paradichlorobenzene

LIME-SULPHUR CONCENTRATE

Lime-sulphur concentrate (33° Baumé), 1 part to 6 or 7 parts water, to which a large excess of lime has been added, is used by some as a deterrent to borers. It is also reported as valuable in protecting trees from attack by mice and rabbits.

ARSENICALS IN BORER WASHES

Lead arsenate or Paris green is sometimes mixed with a wash with the idea of poisoning the larvae which attempt to eat through it. Arsenicals in washes or paints are used with considerable risk of injury to the trees.

PAINT

Probably the best wash for apple-tree borers is a thick coat of paint, made from raw linseed oil and pure white lead. Remove a layer of soil 3 or 4 inches deep from the base of the tree, scrape off the dirt and loose bark scales, and after worming apply to the exposed trunk a thick, uniform coating of the paint to a distance of about 1 foot above the ground. Worming and painting should be done annually in the early part of May, before the beginning of the egg-laying season of the parent beetles. White lead paint has sometimes caused injury, probably on account of inferior ingredients.

GOVERNMENT WHITEWASH

A heavy whitewash, known as the Government formula for whitewash, has been employed with more or less success on trees recently attacked by the fruit-tree bark beetle (*Scolytus rugulosus* Ratz.) (p. 78). It is prepared as follows:

Stone lime	bushel	½
Salt	peck	1
Ground rice	pounds	3
Spanish whiting (plaster of Paris)	pound	½
Glue	do	1
Water	gallons	5

First slake the lime with warm water and then strain it through a fine sieve or strainer. Dissolve the salt in warm water, boil the rice flour to a thin paste, and dissolve the glue in boiling water. Mix the ingredients in the following order and stir well: Pour the salt solution into the lime, then the rice paste, and next stir in, boiling hot, the Spanish whiting and glue, and finally add hot water to make up the 5 gallons of water called for. Stir thoroughly and let it stand for a few days. It should be applied hot with a brush.

MECHANICAL TREE PROTECTORS

Tree protectors of various materials and styles have been long recommended and are more or less used by orchardists. They are intended principally to protect peach, apple, and other fruit trees from attack by borers, mice, and rabbits. They are placed around the tree trunk and extend from a few inches below the surface of the ground to a foot or more above the ground level.

Heavy wrapping paper and tarred paper wrapped around the tree trunk and securely tied with strong twine have been used extensively, as well as protectors made of wooden veneer. Cylinders of wire screening are employed with the idea of preventing the adults of apple-tree borers from depositing their eggs on the lower part of the tree. Close-mesh wire fencing material is also used to keep away rabbits and mice. Repeated trials of various tree protectors have shown that they can not be depended upon to exclude borers to a satisfactory degree, though they are of value against rodents. Hence, if protectors are used and the trees are not regularly wormed, they are likely to become badly infested, the protectors frequently furnishing an ideal retreat for the insects.

A very large number of tree protectors have been patented, but none of these has shown sufficient merit to lead to its adoption to a general extent by orchardists.

BANDING FOR THE CODLING MOTH

Banding the trunks and larger limbs of apple trees with strips of cloth or other materials has been practiced extensively for the control of the codling moth. Previous to the advent of spraying the banding method was the best means known of checking the ravages of this pest, and the bands are still used as an adjunct to spraying in regions heavily infested with the codling moth. This method consists in fastening a band of cloth or other material around the trunk, from which the loose bark has been removed. Usually a band made from burlap folded to three thicknesses from 4 to 8 inches wide is used. A heavy tarred building paper or light roofing paper has also been used somewhat successfully in certain localities. Strips of corrugated paper are very attractive to the worms, but bands of this material must be destroyed and replaced with new ones eight or ten times a season. The codling-moth larvae, or worms, crawl beneath the band to form their cocoons, and these should be destroyed by hand at intervals of 10 days throughout the season.

The Bureau of Entomology has recently worked out a chemical treatment of corrugated paper bands which renders them automatic, the chemical killing practically all worms which enter them. The material found most effective for this purpose is known as beta-naphthol (technical grade), and the bands are coated with a hot lubricating-oil solution of the chemical. This subject is still under investigation, and further details will not be given here. The chief value of the chemically treated bands is in the elimination of the necessity for hand labor during the busy summer season. Hand-worked bands are sometimes neglected during the rush of other operations and under such conditions do more harm than good.

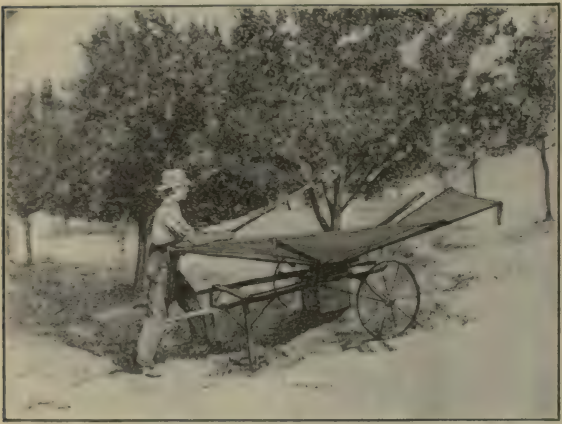

FIGURE 9.—Wheelbarrow curculio catcher. Useful on small trees, such as plums, cherries, and quinces

JARRING INSECTS FROM THE TREES

Certain insects, notably the plum and quince curculios (pp. 67, 76, 77), may be much reduced in numbers by regularly jarring the trees in the early spring and collecting the insects on sheets or special cloth-covered or metal frames. The curculios have a habit of feigning death whenever they are disturbed, and dropping to the ground. Jarring peach and plum trees was at one time the principal method of control of the plum curculio and is still used to some extent as a supplement to spraying in the control of severe infestations.

In the control of the quince curculio jarring is also still practiced. The work is usually started early in the morning while the insects are sluggish and easily dislodged. A wheelbarrow umbrella catcher (fig. 9) is usually employed, though the curculios may be collected on sheets placed on the ground or held beneath the trees. A heavy rap with a padded wooden mallet serves to bring the beetles down. In using the specially designed wheelbarrow umbrella catcher the tree is shaken by striking the trunk with a bumper on the framework of the wheelbarrow at the base of the slit in the umbrella. The beetles slide by gravity to the center of the umbrella into a receptacle containing oil.

BAGGING FRUITS

Choice fruits, especially grapes, may often be protected from insect pests by the use of paper bags placed around the bunches and securely fastened to the supporting shoot or cane. This method is suitable for small vineyards and arbors in reducing injury from the grape-berry moth (*Polychrosis viteana* Clem.), the rose chafer (*Macrodactylus subspinosus* Fab.), and the green June beetle (*Cotinis nitida* L.), but it is too expensive for use on a commercial scale. Bags may be put in place as soon as the blossoms have fallen.

INSECT DESTRUCTION BY FIRE

Gregarious insects, as the eastern tent caterpillar (*Malacosoma americana* Fab.), the fall webworm (*Hyphantria cunea* Drury), and others, can be destroyed in their nests by means of a torch. A handful of rags fastened to a pole and soaked in kerosene will serve for this purpose. The nests should be burned while the caterpillars are at rest within, care being taken not to injure the larger limbs and branches. Egg masses of the gipsy moth and of other insects, deposited on stone walls and in similar situations, can be destroyed by burning with suitable blast or other torches. Cranberry bogs are sometimes burned over in order to destroy certain insects such as the cranberry girdler. This is usually done by specially constructed torches. Leaves and trash in orchards, which frequently harbor injurious insects, should be well plowed under to add to the humus in the soil, or raked up and burned during the fall, winter, or early spring. Great care should at all times be taken not to let the fire get beyond control, as much damage may result to the orchard, as well as to woodlands, buildings, or other property.

BAITS FOR THE CONTROL OF INSECTS

The codling moth and the oriental fruit moth (*Laspeyresia molesta* Busck) may be attracted in large numbers to fermenting solutions of sugar, molasses, malt sirup, and fruit juices, as well as to certain aromatic chemicals. In attempting to feed upon these liquids, many of the moths fall in and drown. Various types of containers have been used, the chief ones being a 1½ or 2 quart stewpan, a gallon-size tin container (painted inside and out to prevent rusting and chemical reactions with the bait materials), and quart glass jars. The stewpan type of container probably attracts the largest number of moths, but evaporation is very rapid, and there is also a considerable loss of bait material in high winds. The glass containers keep the solution in good condition for a longer period of time and do not permit so much loss of material by wind. The baits should be placed as high as possible in the tree, preferably where the foliage is scanty or lacking. In cool weather yeast is sometimes added to the sugar-containing solutions in order to speed up fermentation. Although large numbers of moths may be captured, the value of the traps in control has not yet been established. In the Northwest the bait pans are depended upon for information as to the periods when codling moths are active in the orchards and are invaluable in the timing of spray applications.

A substance known as geraniol has been found to be very attractive to the adults of the Japanese beetle (*Popillia japonica* Newm.), drawing them for distances as great as half a mile. This material has been utilized in traps (fig. 10) designed to capture the beetles and also for the purpose of concentrating the beetles on some valueless vegetation where they may be killed by spraying with a strong contact material.

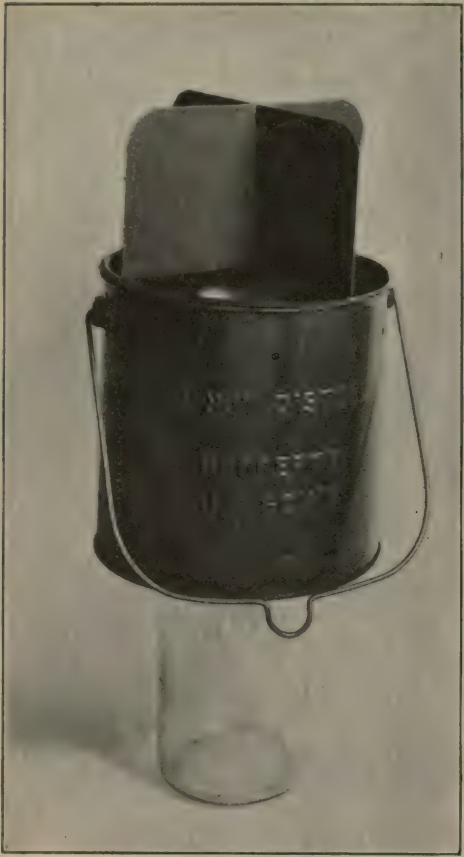

FIGURE 10.—Japanese beetle trap. The beetles, attracted by the geraniol bait, fly to the trap, strike the baffle plates, and drop through a funnel into the glass jar below

INSECT LIGHT TRAPS

It is a well-known fact that certain insects are attracted at night to lights, and in an effort to take advantage of this habit, insect light traps have been recommended at various times for the capture of injurious species. Some of the traps developed are very simple, and others are more elaborate patented contrivances. The small forms consist of an ordinary lantern placed over a basin containing water which is covered by a thin film of kerosene or other oil. The insects in fluttering about the light fall into the oil and are destroyed.

Experiments with light traps in orchards have indicated that these have only slight, if any, value in orchard-insect control. The light traps capture some injurious forms, but at the same time destroy a good many beneficial parasitic and predacious species. Many orchardists have been induced to purchase light traps which were guaranteed to capture the codling moth. This insect, however, has been attracted but little to any light traps thus far devised.

INJECTIONS INTO TREES

Claim is occasionally made, in circular matter issued by financially interested persons and in other ways, of the efficacy in insect and disease control of substances or compounds inserted into holes bored into trees or placed under the bark. Wonderful results have been claimed in some instances from such treatments, and some orchardists and numerous owners of a few yard trees have been induced to have their trees inoculated. No injection treatment has yet been devised that will kill insects without at the same time causing serious injury to the tree. Figure 11 illustrates the injury to a tree resulting from placing under the bark a small quantity of a mixture containing sodium cyanide, common salt, and certain other ingredients.

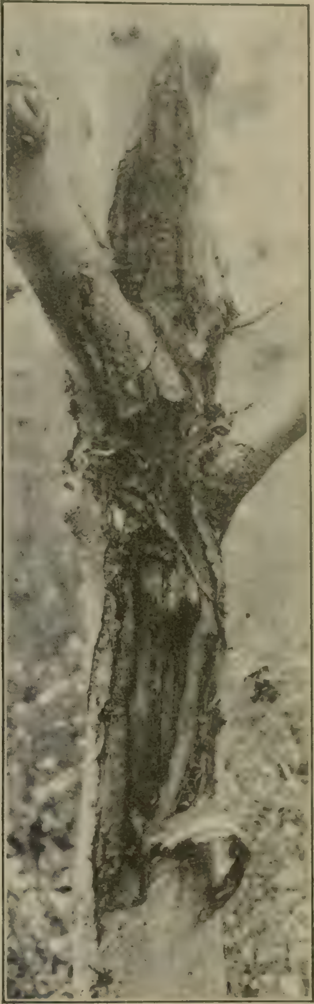

FIGURE 11.—Injury to an apple tree resulting from injection of a cyanide mixture under the bark

TREE-BANDING MATERIALS

Bands of sticky material, 4 to 5 inches wide, applied around tree trunks sometimes may be used to advantage to prevent caterpillars, climbing cutworms, and certain other insects from climbing the trees. These bands are also employed to prevent nonflying and wingless moths, such as the gipsy moth, cankerworm moths, tussock moths, etc., from ascending trees to deposit their eggs. Cotton batting and wire screen also are used in making protective bands.

The indiscriminate use of these bands, as well as of mechanical barriers, is to be discouraged. They are sometimes seen in parks on trees which are not subject to attack by insects against which they would have any value. As a rule it is advisable to obtain advice as to their use from entomologists.

These sticky bands are sometimes injurious to the tree, but injury may be avoided by spreading the adhesive on a strip of heavy paper encircling the tree trunk. A form of band that has given satisfactory results is made from cheap cotton batting and single-ply tarred building paper. The cotton should be cut into strips about 2 inches wide and wrapped around the tree trunk so as to fill all the crevices of the bark. Over the cotton is placed a strip of tarred paper about 5 inches wide, drawn tightly and securely tacked where it overlaps. The sticky material is then spread on top of the paper. (Fig. 12.)

The sticky substance must be renewed from time to time, since when it dries out or becomes covered with dust or insects it fails as a barrier to crawling insects. If a combing instrument is occasionally drawn over the band, it will serve to lengthen the usefulness of the band by bringing some of the sticky portion to the surface.

Sticky fly paper is used sometimes in place of the sticky bands. This may be attached to the trunk by means of heavy twine tied tightly around the upper and lower edges and serves best if put over a strip of cotton as just described.

AXLE GREASE, FISH OIL, AND ROSIN BANDING MATERIAL

A tree-banding material used in Europe, reported as effective, is made as follows:

Axle grease	pound	1
Fish oil	pint	1
Powdered rosin	pounds	2

Heat the axle grease, to remove all of the water contained therein, in a cooking vessel having a capacity of at least 1 gallon. Then stir in the fish oil and finally the powdered rosin a little at a time. When the latter is dissolved, remove from the fire. The mixture is ready for use the next day. Apply to tarred-paper bands as already described.

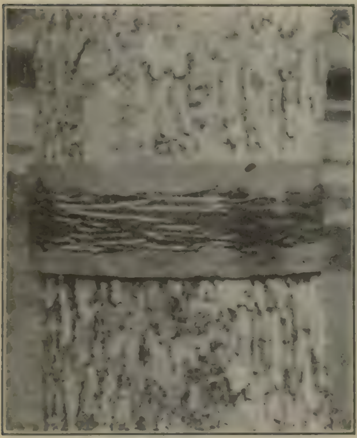

FIGURE 12.—Barrier of sticky material on tree trunk to prevent ascent of caterpillars, wingless moths, etc.

GIPSY MOTH TREE-BANDING MATERIAL

The preparation of a tree-banding material which has been developed for use in the control of the gipsy moth is described in detail in United States Department of Agriculture Bulletin 899, Gipsy Moth Tree-Banding Material: How to Make, Use, and Apply It, which should be consulted by any fruit grower who has occasion to use large quantities of sticky banding material. The bulletin may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C. Price 15 cents.

Several other sticky substances, homemade and proprietary, are used.

PRINTER'S INK

Printer's ink which is sold as "tree ink" usually consists of refuse ink and should be mixed with a heavy oil to prevent its drying out too quickly. Apply as described for other tree-banding materials.

COTTON BATTING

Barriers other than sticky bands are sometimes used to prevent insects from crawling up trees. Bands of cotton batting about 6 to

8 inches wide are effective as long as the cotton remains fluffy. Wrap the band around the tree trunk and securely tie the bottom edge by means of stout twine. The upper edge should then be turned down over the string, forming a flange of loose cotton all around the tree. (Fig. 13.)

WIRE SCREEN

Cankerworm moths, tussock moths, gipsy moths, and other non-flying moths may be prevented from crawling up the trees by a wire screen (ordinary fly screen, 12 meshes to the inch) tacked around the tree trunk. Cut the wire screen into strips 12 inches wide and sufficiently long to encircle the trunk. Tack the upper edge of the screen so that it fits snugly to the bark and allow the lower edge to extend out a distance of 1 to 2 inches from the trunk. The moths will crawl up into the screen trap and may be crushed daily by hand. This device, however, does not prevent the ascent of trees by any young larvae hatched from eggs deposited by the captured moths below the barrier, and hence the sticky bands are more effective.

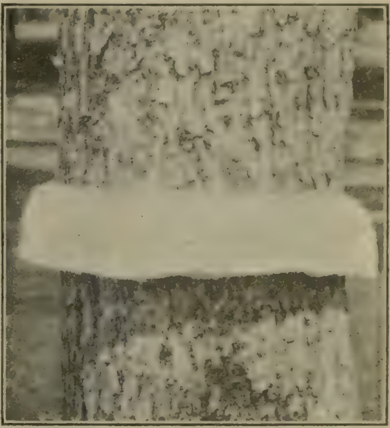

FIGURE 13.—Barrier of cotton batting on tree trunk to prevent ascent of caterpillars, wingless moths, etc.

TREATMENT OF TREE WOUNDS

Wounds due to removal of large limbs, or to injury from any cause, as by rabbits, field mice, plows, etc., around the base of trees, should be promptly disinfected and treated with a waterproof covering. An exposed surface is subject to attack by fungi and invasion by wood-boring insects unless properly cared for. After a limb is cut off, the wound should be treated with a disinfectant, such as common creosote, which will penetrate and sterilize the wood. This may be applied with a small brush. After creosoting, the wood should be protected from moisture by means of a heavy coat of coal tar. Instead of using the materials separately, they may be combined as a mixture containing creosote and coal tar. Add enough creosote oil to the coal tar to bring it to the consistency of thick paint (approximately 1 part creosote to 3 parts of coal tar). One coat of the mixed materials may be sufficient, but, if not, a heavy application of the coal tar should be used, and the surface recoated whenever it is found cracking or breaking away from the wound. A pure white-lead and linseed-oil paint is sometimes employed for tree wounds, and, although not so satisfactory as the coal-tar-creosote paint, it is a good deal better than nothing. Ordinary grafting wax will give good results for small surfaces. A paint prepared by mixing dry Bordeaux with linseed oil has also been used for treating tree wounds.

TREATMENT OF TREE CAVITIES

Decayed cavities in the trunk or limbs are frequently infested with wood-boring larvae or are the retreat of different species of ants. Such cavities are objectionable, for not only do they favor gradual decay and weakening of the trees but also they afford an excellent winter harbor for such insects as the codling moth. As noted below, cavities in the trunk usually are the result of improper pruning and neglect to care for wounds from other causes. Such cavities should be cared for.

The first operation is to remove all the decayed wood. This can be done by means of a gouge, chisel, mallet, and knife. The cavity should be drained, either by cutting a V-shaped point at the bottom, where practicable, or by boring a small hole to serve as a drainage outlet. In cutting around the edge of the cavity nothing but very sharp tools should be employed, as dull instruments will injure the cambium. After the cavity has been thoroughly cleaned out it should be treated with the creosote-coal tar mixture as previously described. Repaint every year or two if necessary until danger from further decay has passed.

PRUNING

Twigs and branches of orchard trees, when heavily infested with or injured by insects, frequently can be removed in the course of pruning operations. Also in pruning thought should always be given to maintaining the shape of the trees to facilitate the application of sprays.

In cases of severe insect injury large trees sometimes should be severely cut back or "dehorned" in order to produce new healthy wood. This also brings the trees to a size more convenient for spraying. With old trees, however, too much wood should not be removed at one time, and the dehorning process should be extended over two or three years. Small limbs and twigs incrusted with scale insects or punctured by the periodical cicada (*Tibicina septendecim* L.), tree hoppers, or other insects, usually may be removed to advantage. Pruning should be done preferably before the application of dormant tree sprays, since it is a waste to use spray materials on limbs and branches that are to be removed later, and the spraying may be done more thoroughly after the removal of the excess wood.

All dead trees and limbs should be promptly removed and burned, as wood-boring insects breed in them and may become abundant enough to attack and injure near-by healthy trees. When limbs of trees are being removed, they should be sawed as close to the trunk as possible to insure rapid and complete healing over. Stubs of limbs should not be left, as these decay, later resulting in a cavity which permanently injures the tree and affords a hiding place for noxious insects. In cutting large limbs special care should be taken to prevent stripping of the bark from the trunk. A large limb is best removed by first sawing the limb from the underside at a distance of 6 or 8 inches from the trunk until the saw is pinched, by which time the cut should have reached from one-fourth to one-half through the limb. The second cut should be made on the upper side of the limb an inch or two farther from the base of the limb than the first one, sawing being continued until the limb falls. It is then easy to saw off the stub close to the tree trunk, and in line with its woody surface, taking care, however, to support the stub until completely severed.

STIMULATION OF GROWTH BY FERTILIZATION

Unthrifty trees, vines, and other plants are thought to be more subject to the attack of certain insects than plants in a healthy condition. Weakened trees are frequently killed by wood-boring insects which do not attack trees growing vigorously. Such trees sometimes can be saved by prompt stimulation with a nitrogenous fertilizer, as nitrate of soda, stable manure, etc. This treatment, in connection with severe pruning and adequate cultivation, especially in the case of stone fruits, will often result in their marked improvement.

Cultivation late in the season, however, may stimulate a late growth, which is especially subject to winter injury. In the case of the peach orchard, too vigorous a late growth is also undesirable from the standpoint of the control of the oriental fruit moth, as it furnishes the insect with succulent young growth after harvest, when it might otherwise fail to find favorable food.

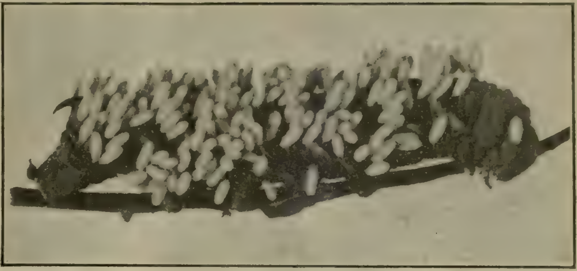

FIGURE 14.—Sphinx caterpillar bearing cocoons of a small, 4-winged, wasplike parasite. These cocoons are often mistaken for eggs. Slightly less than natural size

CULTIVATION

Many fruit-insect pests which pass part of their life in the soil, such as the plum curculio (*Conotrachelus nenuphar* Herbst), spring cankerworm (*Paleacrita vernata* Peck), and grape rootworm (*Fidia viticida* Walsh), can be materially reduced in numbers by thorough cultivation such as is necessary in the best orchard practice. When these insects are in the pupa stage in the soil they are very susceptible to injury, and thorough cultivation causes many of them to succumb.

THINNING OF FRUIT

In the course of thinning fruit in order to insure larger size and better quality, much can be done to reduce the numbers of certain insect pests, such as the codling moth and curculio, if the infested fruit be searched for and removed from the trees and promptly destroyed by feeding to hogs, or otherwise. Special care should also be given in thinning to remove as far as possible fruits showing blemishes of various kinds, as from injury by aphids, plant bugs, etc., thus giving the sound fruit a better chance. The unsprayed surfaces where apples are in contact in clusters are favorite feeding grounds for many insects, and the reduction of clusters to single apples makes possible a more complete covering with spray materials, resulting in better control.

PARASITIC AND PREDACIOUS ENEMIES OF INSECTS

Most species of noxious insects are subject to attack by one or more—usually several—parasites or predatory enemies, and these natural agencies are very important factors in their control. Entomologists have given much attention to the possibility of arraying one insect against another, and in certain cases such efforts have met with pronounced success. A recent effort of this nature has been the attempt to rear an egg parasite of the codling moth on the eggs of one of the grain moths (which can be reared in large numbers the year round) and to liberate these parasites (*Trichogramma minutum* Riley) in the orchards in sufficient quantity to effect a control of the codling moth. These interesting efforts have not yet reached the point where the success of the operation on a commercial scale is assured. In the case of most orchard insect pests, however, artificial means, such as spraying, must be relied upon for their control, although the orchardist should encourage his insect and other friends as much as possible.

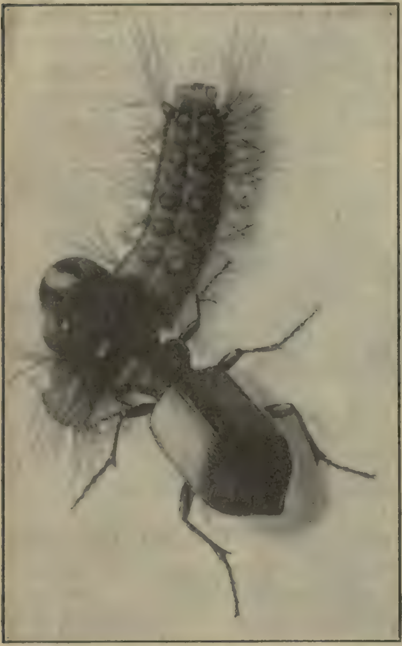
FIGURE 15.—Caterpillar of gipsy moth (*Porthetria dispar*) attacked by the Calosoma beetle (*Calosoma sycophanta*). Slightly greater than natural size

Owing to their diminutive size parasitic insects, especially the little 4-winged flies (fig. 14), are not usually observed by the fruit grower. His predatory insect friends, however, such as tiger beetles, ground beetles (fig. 15), ladybird beetles, etc., are more evident.

Birds are among the more important natural checks to insect life, and certain species especially frequent orchards. Woodpeckers are well known for their ability to dig out insects, and certain species are valuable aids in the destruction of the codling moth and other insects concealed beneath the bark. Other insectiverous birds frequenting orchards are warblers, creepers, titmice, flycatchers, quails, doves, etc.

The common toad is an enemy of numerous insects. Approximately 98 per cent of its food is of animal origin, and much over 60 per cent consists of injurious insects. The toad feeds during the evening and night and in 24 hours consumes an amount of insect food equal to about four times the capacity of its stomach. Numerous important insects have been found in its stomach, as the plum and apple curculios, tent caterpillars, cankerworms, gipsy-moth caterpillars, and even caterpillars of the brown-tail moth (*Nygmia phaeorrhoea* Don.) with their poisonous hairs.

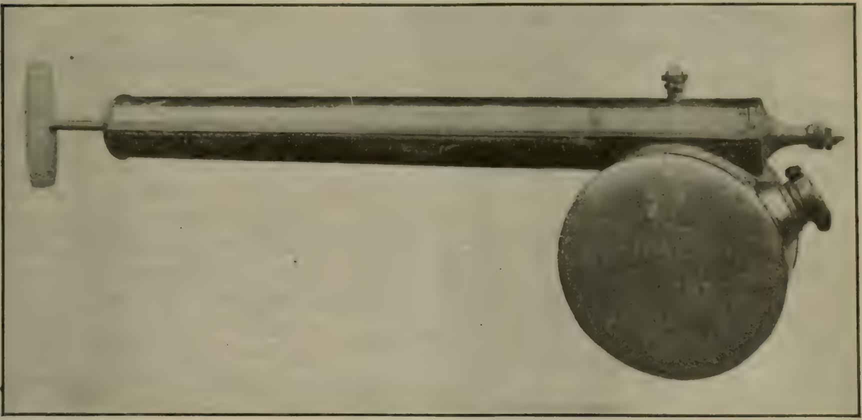

FIGURE 16.—Hand atomizer, useful for spraying a few small plants

Domestic animals sometimes may be utilized in insect control. Hogs are useful in consuming fallen, infested fruit in orchards, though the trees are frequently damaged by them. Chickens and turkeys in orchards accomplish much good in the destruction of various insects on the ground, as curculios, certain caterpillars, and the like.

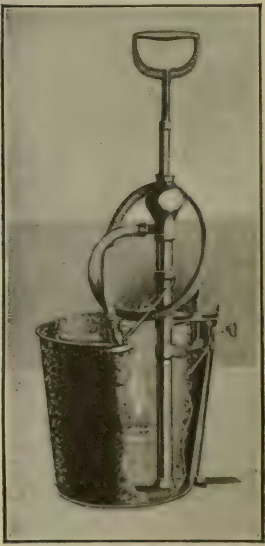

FIGURE 17.—Bucket pump, suitable for spraying a few plants and low-growing trees in home grounds. A longer lead of hose is desirable if a second person is available to do the pumping

SPRAYING OUTFITS FOR SMALL OPERATIONS

HAND ATOMIZERS

For spraying a few plants or very small trees hand atomizers may be used. These are made of brass, copper, heavy tin, or other material, and usually have a capacity of about 1 quart. (Fig. 16.)

BUCKET PUMPS

Bucket pumps (fig. 17) are fairly convenient and satisfactory for spraying small gardens and shrubs or small trees. They should be of brass or other noncorrosive metal and preferably should be equipped with an agitator. In some pumps agitation is provided by means of a small jet of the liquid which squirts from the bottom of the pump into the liquid as the pump is operated. For convenience in spraying, these pumps may be clamped to the bucket or used free in a tub or other vessel containing the spray material. They should be supplied with a spray rod and sufficient hose to spray conveniently the plants to be treated.

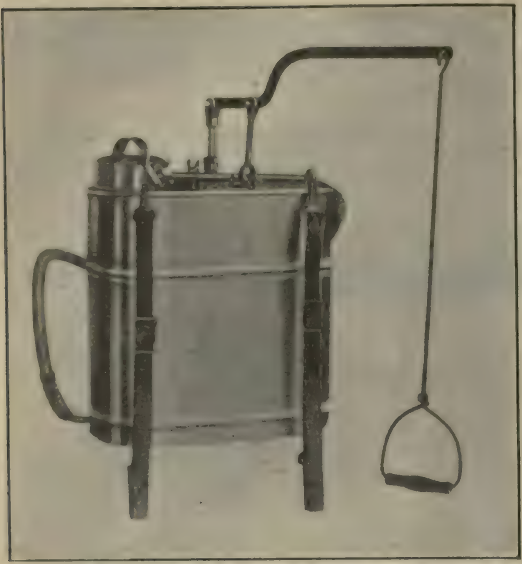

FIGURE 18.—Knapsack pump for spraying on a small scale; not extensively used now

KNAPSACK PUMPS

A knapsack pump (fig. 18) may be used for small spraying operations. These pumps have a capacity of about 4 gallons and are provided with an air chamber to insure pressure and a steady spray. They are carried on the back of the operator and pumped by one hand, while the other is used to hold the spray rod.

SMALL COMPRESSED-AIR PUMPS

Compressed-air pumps (fig. 19) are frequently used in small fruit gardens and are preferred to the bucket or knapsack pumps by those who do not wish to pump while applying the spray. These pumps are usually made of brass or galvanized sheet steel and have a capacity of 3 or 4 gallons. They are carried by means of a shoulder strap. In the better types agitation is provided, usually by the entrance of the air at the bottom of the tank. After the spray material is poured into the tank and the opening closed by the tight-fitting cap, the air is pumped until the liquid is under pressure. Three to four pumpings of a dozen strokes each will usually discharge all the liquid in the tank.

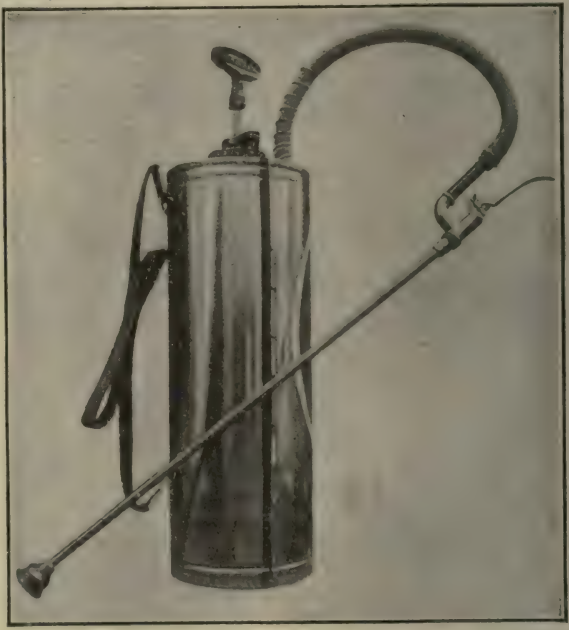

FIGURE 19.—Compressed-air sprayer for small spraying operations; no pumping is required while spraying

BARREL PUMPS

The barrel hand-pump outfit (fig. 20) has a capacity of about 50 gallons and has come into extensive use for the home orchard or fruit garden. With a good barrel pump considerable spraying may be done in a satisfactory manner. The working parts of the pump should be of bronze, brass, or other noncorrosive material, and the valves and plungers should be readily accessible and easily repaired. The pump should be provided with an efficient agitator, either of the paddle or rotary type. To insure a good pressure and uniform discharge of the spray material the pump should be provided with an adequate air chamber, to which a pressure gauge may be attached if desired. The pump may be mounted either on the head or side of the barrel, and the whole outfit placed on skids or on a wagon or truck. On hilly land it is preferable to have the barrel in a horizontal position.

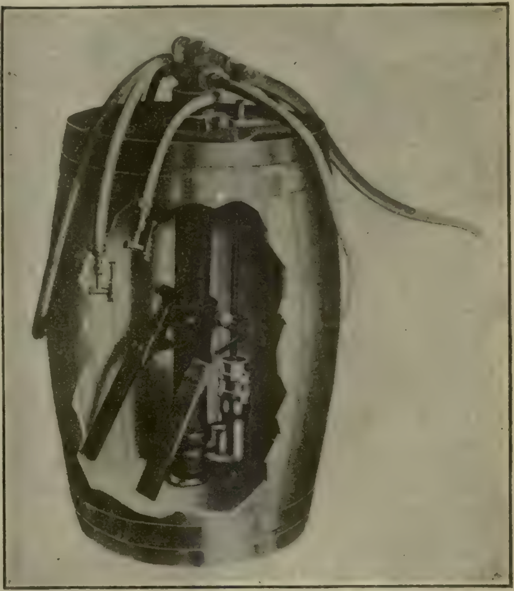

FIGURE 20.—Barrel pump, suitable for spraying the fruit garden or home orchard

DOUBLE-ACTION HAND PUMPS

The double-action hand pumps (fig. 21) are usually employed in connection with spray tanks of greater capacity than a barrel, such as the 150 or 200 gallon half-round tank used in place of the wagon bed. The pump, which may be either vertical or horizontal, is fastened to a small platform and placed on top of the tank or on a platform at the rear end of the wagon. A suction hose extends into the spray tank. A barrel or 100-gallon hogshead may be used, however, and placed at one end of the wagon bed or platform, thus leaving plenty of room for the pump and operator. When properly used these double-acting, double-cylinder pumps furnish adequate pressure for two leads of hose, and for single or double nozzles. They furnish an outfit intermediate in cost and capacity between the barrel pump and the gasoline or other power sprayer. A common defect is lack of adequate facilities for agitation, although tanks are available in which this deficiency is corrected to some extent.

SPRAYING OUTFITS FOR LARGE OPERATIONS

Spraying outfits for commercial orchards and vineyards are generally operated by gasoline engines, although traction sprayers and compressed-air outfits also are in use.

TRACTION SPRAYERS

In the traction type of sprayer (fig. 22) the pump is geared to, or connected with, the wheels, and the pressure is generated while the spray rig is moving. These sprayers are used chiefly for low-growing crops but are sometimes used in vineyards. The difficulty of providing for sufficient pump capacity and pressure is a serious objection to the traction type of sprayer for orchard and vineyard use.

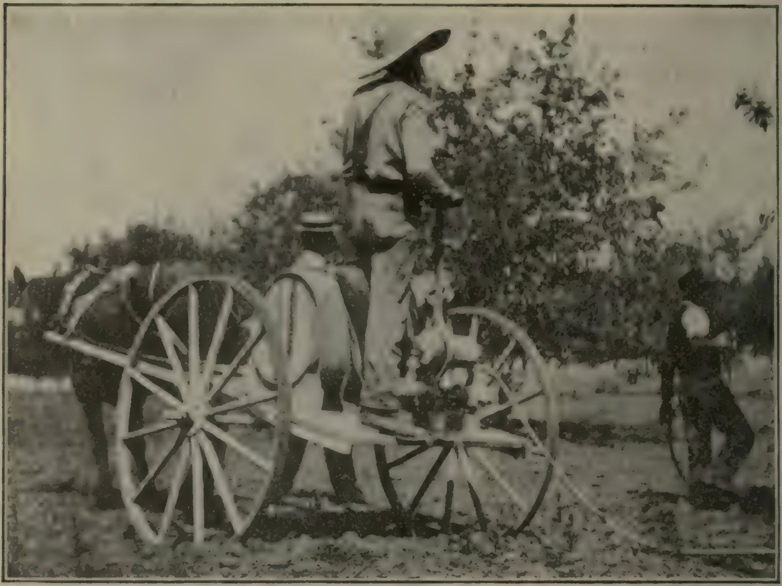

FIGURE 21.—Double-action hand pump for spraying home orchard or small commercial orchard

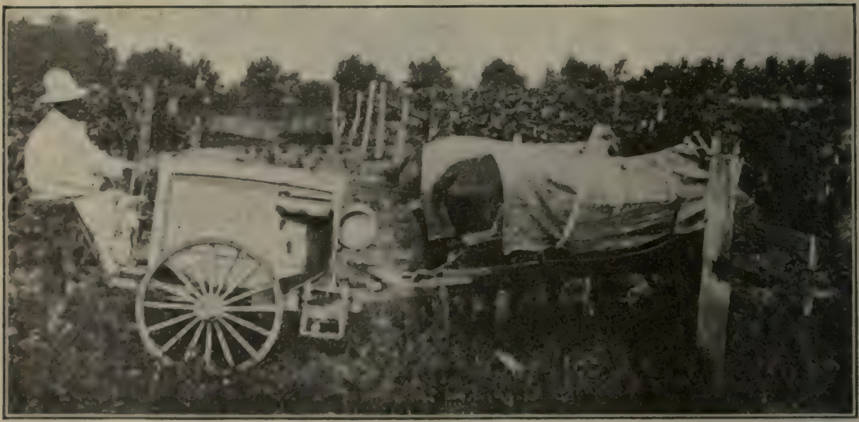

FIGURE 22.—Traction sprayer, pump being geared to the wheels. Pressure is usually inadequate with this outfit

COMPRESSED-AIR SPRAYERS

Compressed-air sprayers have been used more or less in orchard spraying but are much less popular than gasoline-power outfits. Compressed-air sprayers (fig. 23) are mounted low, and owing to their small size and light weight may sometimes be used to advantage on steep hillsides where the ordinary power sprayers are impracticable. The compressed-air outfit consists of two tanks, one for the air and the other for the spray material. As the air is released into the spray tank, the spray material is forced out under a constantly decreasing pressure. The air tank is charged at a central pumping station by means of a compressed-air pump.

GASOLINE-POWER SPRAYERS

Spray pumps operated by gasoline engines are by far the most efficient type of sprayer and are made in various sizes and styles to suit almost any requirement. Special outfits have been designed for hillside spraying, vineyard spraying, shade-tree spraying, etc.

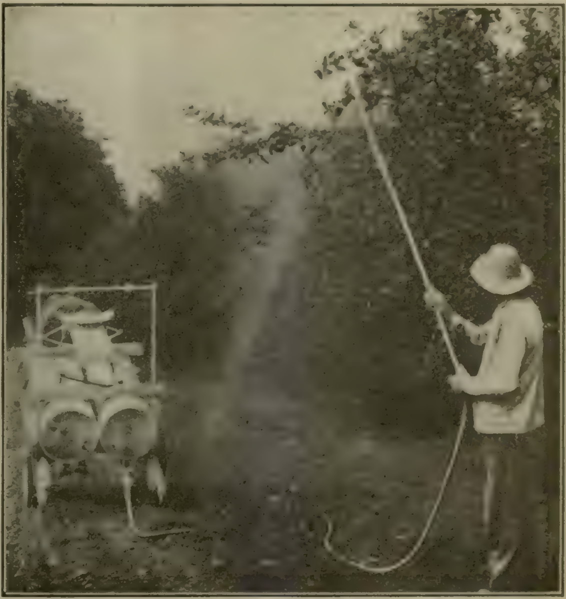

FIGURE 23.—Compressed-air sprayer, not much used except in orchards planted on steep, rough hillsides

The smallest power sprayers are nothing more than an ordinary barrel pump equipped with a small engine of 1 to 1½ horsepower. These small mechanical outfits are higher in price than the hand pump, but are usually worth the additional first cost. They may be operated at a comparatively small cost and will give a steadier spray and higher pressure than will the pumps operated by hand. With the small power outfit one lead of hose is generally used, but two leads may be employed if the pump has sufficient capacity.

Large power sprayers (fig. 24 and title-page illustration) are made with pumps of from two to four cylinders, having a capacity of from 10 to 25 or more gallons per minute under a pressure of 200 to 500 pounds. These sprayers are operated by gasoline engines of from 4 to 15 horsepower. For the 3 and 4 cylinder pumps of large capacity, auto-type 4-cylinder engines of from 10 to 15 horsepower are sometimes used.

The spraying outfits used by the majority of commercial orchardists consist of a 3 or a 4 cylinder pump with a capacity of from 10 to 20 gallons of spray material per minute and furnish a pressure of from 225 to 350 pounds. These outfits are equipped with gasoline engines of from 4 to 6 or more horsepower and usually are provided with a 200 or 300 gallon tank and an effective agitator.

A number of reliable and efficient power sprayers are now available on the market, the various makes differing from each other in many details of construction. The fruit grower, before selecting an outfit, should consider carefully the several designs and choose an outfit that will best meet his requirements. An important factor to be considered is the readiness with which repair parts may be obtained when breakdowns occur. Delays at critical times during the spraying season are costly because of failure to get the job finished in time for effective control, as well as in actual time lost. Most of the leading manufacturers of spray machinery maintain supplies of repair parts at central points in all commercial fruit regions.

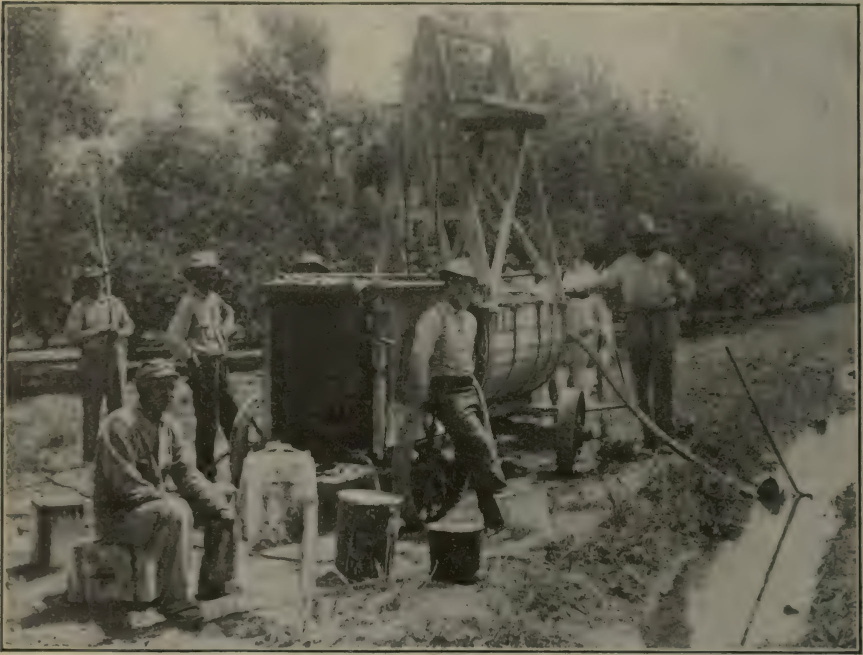

FIGURE 24.—Gasoline-power spraying outfit with carpenter's horse type of tower and rotary-pump tank filler

STATIONARY SPRAY OUTFITS

In some sections many growers are installing stationary spray outfits. Instead of hauling a heavy spray rig with its load of liquid through the orchard, the material is pumped from a central plant through a system of piping over the entire orchard, and the spray men merely attach leads of hose to the various outlets provided at suitable intervals through the orchard. In most cases a 100-foot length of hose is used, and one man sprays while another assists in dragging the hose around. Growers who have adopted this system have found that it has many important advantages, effecting a material reduction in spraying costs, increasing the daily output of spray material, and avoiding interference with irrigation or cultivation practices. Spraying can proceed whenever the time is right for it, irrespective of ground conditions. Since the pump and engine (or electric motor in case current is available) are permanently installed on a substantial foundation, much less trouble is experienced with the machinery, and the equipment is much less subject to wear and tear than when it is being jolted and bumped through the orchard. Orchardists considering the installation of stationary outfits should investigate the subject carefully and secure advice, if possible, from those who have such outfits in use.

DUSTING APPARATUS

The application of insecticides in the form of a dry dust has already been mentioned (pp. 9–10, 16, 25).

Apparatus of various styles and adapted to a wide range of use for applying insecticidal dusts to plants is available on the market.

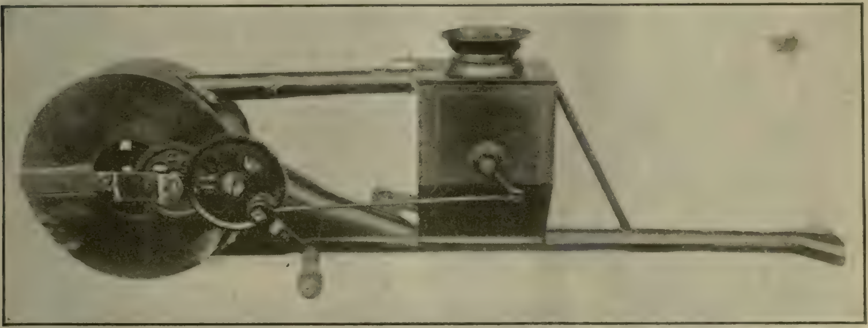

FIGURE 25.—Hand duster for applying dust mixtures in the fruit garden

HAND DUSTERS

There are several types of small dusters for treating low-growing plants, such as currants, grapes, bush fruits, and even small fruit trees. In the bellows type the air blast is generated by a bellows; in the cylinder type a piston and piston rod are utilized to make the air blast. A larger hand duster (fig. 25), suitable for rather extensive dusting operations on low-growing plants, is furnished with a fan operated by gears or by a belt from a hand crank.

The largest type of hand duster is usually mounted on a platform to be placed on a wagon or truck and is suitable for the home orchard or small commercial orchard. Machines of this type, however, are rather difficult to operate and have not come into general use.

POWER-DUSTING OUTFITS

Power dusting outfits (fig. 26) are for use in large commercial orchards. The dusters are usually operated by a 3 to 8 horsepower gasoline engine. The essential parts are the hopper, feeder, air chamber, fan, and discharge tube. The dust mixture is poured into the hopper, from which it is fed into the air chamber, where it is caught by a strong current of air generated by the rapidly revolving fan and is forcibly expelled through the flexible discharge pipe. These outfits are provided with a clutch-controlling lever and a device for regulating the amount of material discharged. Some dusting outfits are now equipped with a self-contained mixing device. Dust materials in the proper proportions are poured into the hopper and are thoroughly mixed before being discharged.

SPRAYING ACCESSORIES

The spraying outfit is not complete or efficient unless properly equipped with useful accessories. Spraying devices that will save time or aid the fruit grower in doing more thorough work should be provided. The equipment need not necessarily be elaborate or expensive but should be sufficiently complete and modern so that the orchardist will not be handicapped when the time to spray is at hand. Spraying, to be most effective, must be done at critical periods, and delays caused by insufficient or inferior equipment may mean a heavy monetary loss.

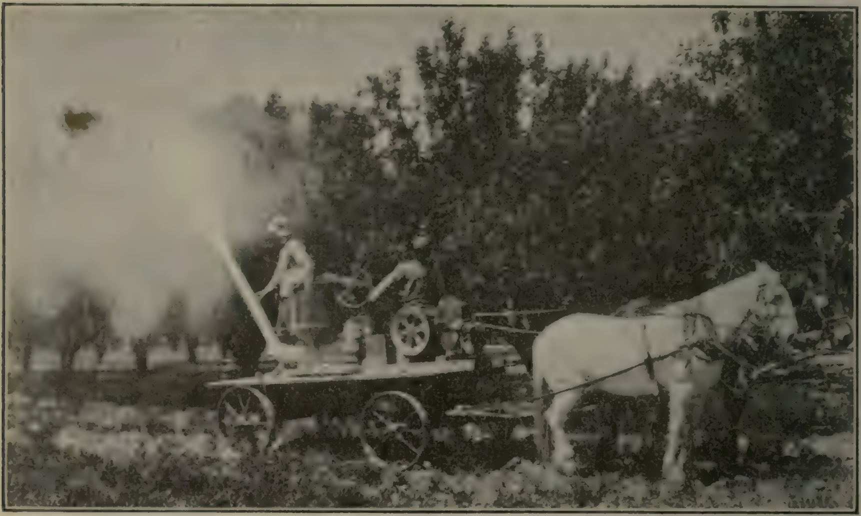

FIGURE 26.—Large dusting outfit for use in commercial orchards

SPRAYING TOWER

Large trees can be more effectively sprayed with the aid of a tower that will enable the spray-rod operator to reach the higher parts of the trees and to see where and how he is applying the spray material. The height and shape of the tower will depend upon the size of the trees and the distance between the rows. Square or oblong towers (cover page illustration), built over the spray tank, are most frequently used, but in orchards where the trees are close together a tower on the order of a carpenter's horse (fig. 24) will serve the purpose better. With the latter form, a platform is built at a height to permit the operator to straddle the padded horse. The towers are usually constructed of wood, steel, or iron.

SPRAY RODS

Extension rods (figs. 27 and 28) are often employed, especially with hand sprayers and with the smaller-capacity power outfits in order to reach the upper and inner parts of the trees. These generally consist of an aluminum or brass pipe contained within a bamboo pole and are made in lengths of from 6 to 12 feet. Some fruit growers use an ordinary gas pipe, but the lighter-weight spray rods are more desirable.

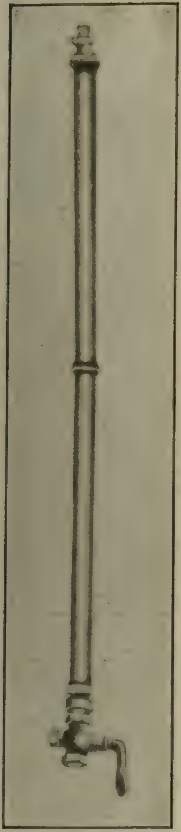

FIGURE 27.—Bamboo spray rod with cut-off

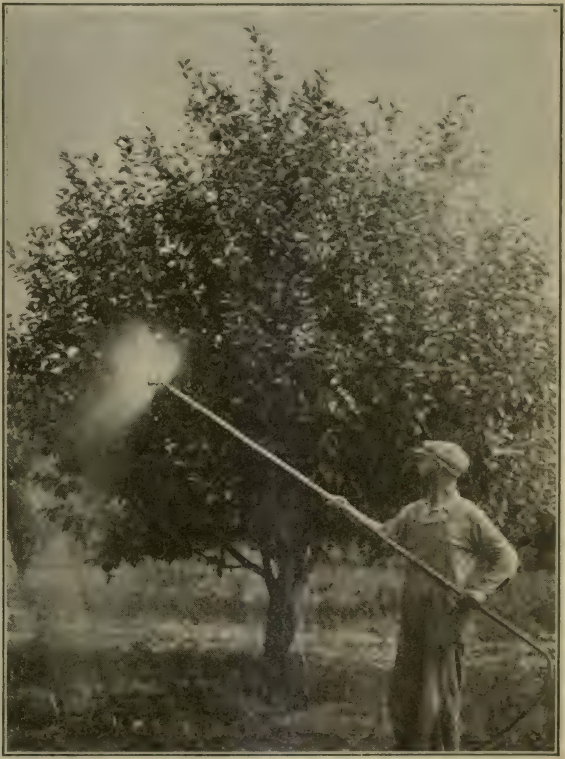

FIGURE 28.—Spray rod with double angle and disk nozzles

SPRAY NOZZLES

The whirlpool or disk type of nozzle (figs. 29 and 30) is the most popular and useful for general orchard spraying. With this type of nozzle the spray material enters an eddy chamber at a tangent, causing the liquid to whirl rapidly. The spray escapes through a small opening in the center of the disk at the top of the nozzle, producing in most cases a hollow, cone-shaped spray, although some nozzles have been designed to produce a more or less solid cone. The disks are removable and can be changed whenever desirable, as when the openings have become too large on account of wear. Disks may be obtained with openings of various sizes, permitting the use of the size best adapted to the particular spray being applied, or to the capacity of the outfit with which it is used. The disks with large holes deliver the larger quantities of material and should not be used with pumps of small output and pressure capacity, being especially unsatisfactory for use with hand outfits. The disk nozzles are relatively small and compact and owing to the absence of any appendages do not catch in the branches of trees.

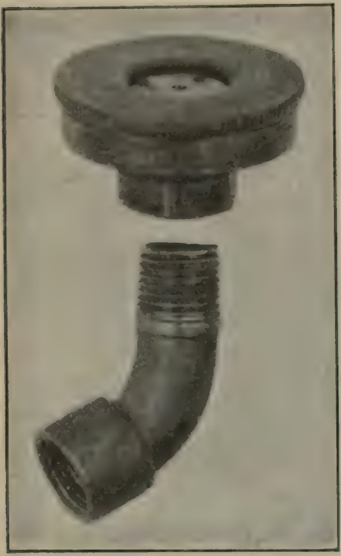

FIGURE 29.—Large eddy-chamber or whirlpool-disk type of nozzle and elbow or crook

Disk nozzles are usually made either straight (fig. 29) or angled (fig. 30). The latter throws the spray at an angle to the spray rod, is convenient for most spray work, and is especially desirable for the calyx application for the codling moth. The straight nozzles can be attached to an elbow (figs. 28 and 29) or nozzle crook in order to obtain the same results.

The original whirlpool nozzle is commonly known as the Vermorel nozzle, and as now constructed is provided with a degorger for use in cleaning the nozzle when clogged. This nozzle gives a very fine misty spray with low pressure and therefore can be used to advantage with spray pumps of small pressure capacity. The Vermorel nozzle is made singly or in clusters of 2 (fig. 31), 3, or 4 nozzles. These clusters are often a source of annoyance in orchard spraying, since they frequently catch in the twigs.

Another type of nozzle which was formerly much used is the Bordeaux nozzle. (Fig. 32.) This may be adjusted to give a relatively fine fan-shaped spray, a coarse driving spray, or even a solid stream, with all gradations between. Bordeaux nozzles do not easily clog and may be readily freed from coarse spray particles or other sediment by turning the barrel by means of the small handle on the side of the nozzle. These nozzles deliver a large quantity of material, and in order to insure a satisfactory spray the pump must have ample capacity, and a high pressure must be maintained. The Bordeaux type of nozzle has been frequently recommended for the calyx application for the codling moth to secure a coarse, driving spray. It is not so convenient to do orchard-spray work with the Bordeaux nozzle as with the whirlpool or disk types, since the handle of the former frequently catches in twigs.

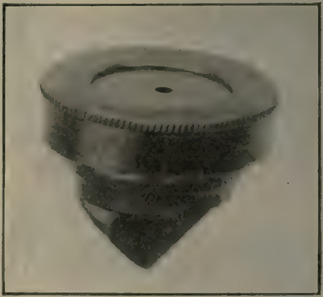

FIGURE 30.—Angled nozzle of the eddy-chamber or whirlpool-disk type

NOZZLE Y

For rapid spraying, with outfits having sufficient capacity and pressure, two nozzles per rod may be used. These can be attached to the spray rod by means of a Y. The Y's are made straight for angle nozzles or curved for straight nozzles.

SPRAY GUNS

In recent years, a number of improved devices have been invented for the application of spray materials, and certain of these are referred to as spray guns. (Figs. 33, 34, and 35.) The spray gun consists of a short metal rod, from 2 to 4 feet in length, through which the spray may be thrown a distance of 10, 15, or even more than 20 feet. These are much easier to handle than the cumbersome spray rods and in the hands of careful operators have given very good results. The nozzle itself is of the whirlpool or disk type, but is considerably larger than the ordinary disk nozzle, and has a much larger opening. Most of the guns are adjustable, so that the spray may be varied by the operator from a fine mist for application at short range to a coarse, driving spray approaching a solid stream for reaching branches at some distance. (Fig. 33, A and B.) When such a coarse stream strikes near-by branches, there is considerably more danger of injury to the foliage than with the application of a fine mist.

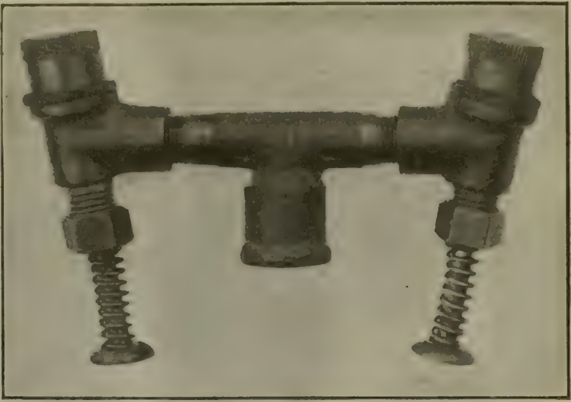

FIGURE 31.—Cluster of two Vermorel (eddy-chamber type) nozzles equipped with degorger. These nozzles often cause trouble by catching on branches

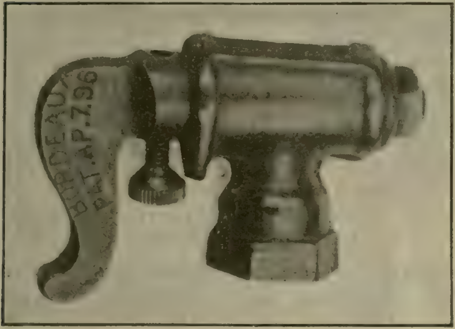

FIGURE 32.—Bordeaux nozzle, formerly much used for applying the calyx spray

Several devices have been developed which are intermediate between the short spray gun and the long rod, and which retain some of the best features of both. One of these (fig. 34) is a gun approximately 6 feet in length, with a slight bend toward the end, permitting the application of the spray from a greater number of directions than is possible with a short, straight gun. As with the short gun, this device permits the operator to vary at will the character of the spray delivered.

A second intermediate device, sometimes referred to as a "nozzle cluster gun" (fig. 35), consists of three or four large-capacity disk nozzles mounted at right angles to a short section of pipe, the whole nozzle head being mounted on a metal rod from 4 to 8 feet in length. This device delivers a driving but mistlike spray which carries a distance of 10 or 15 feet from the opening with sufficient force to turn the leaves and to some extent place spray material on both surfaces.

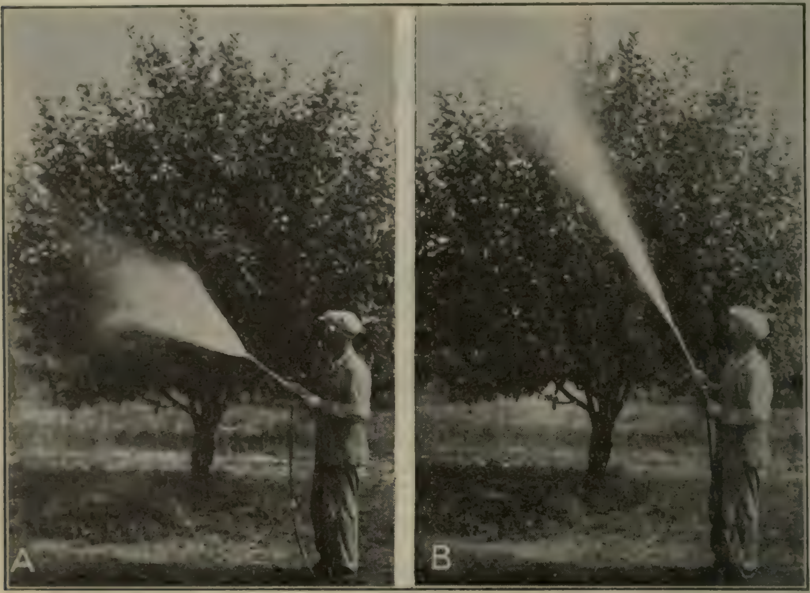

FIGURE 33.—A short spray gun: A, adjusted to deliver a fine mist at close range; B, the same gun adjusted to reach into the top of trees and to foliage some distance from the operator

SHUT-OFF

A shut-off between the spray hose and the base of the spray rod is a convenient device, permitting the operator to avoid waste of spray liquid by cutting off the flow in passing skips in the orchard, or between trees when they are spaced far apart. The use of a shut-off also facilitates the unclogging of nozzles when necessary. Some shut-offs are constructed with an angle, which permits the hose to hang in its natural position and thereby reduces the amount of wear on the hose at the coupling.

SPRAY HOSE

Only the best-grade high-pressure hose, usually about three-eighths to five-eighths of an inch inside diameter, should be used for spraying operations. The length of the hose for the men spraying from the ground will vary according to conditions, but should be adequate for the work to be done. In commercial orchard spraying, 50 feet of hose is desirable, and this will be long enough to permit the spray men to work around the tree without hindrance. The length of the hose for the tower will depend upon the height of the spray tower. For use with stationary spray outfits, 100-foot leads of hose are usually employed.

HOSE COUPLINGS AND CLAMPS

It is poor economy to use lightweight hose couplings and clamps, since rough usage will soon cause them to break or blow out. Heavy couplings and clamps are obtainable, and these will give better satisfaction.

TANK FILLERS

During spraying operations it is highly important to refill the spray tank quickly, since delays in filling waste the time of the team and spray men. Unless the commercial fruit grower is provided with a convenient pressure or overhead water system, a tank filler is practically indispensable. This device, which usually operates on the jet system, will promptly fill the tank from any source of water, such as a cistern or pond. Rotary pumps connected with the spray engine are employed for the same purpose and are more satisfactory where the water contains considerable sediment. Rotary pumps are frequently used in the western fruit-growing districts where the water is drawn from the irrigation ditches.

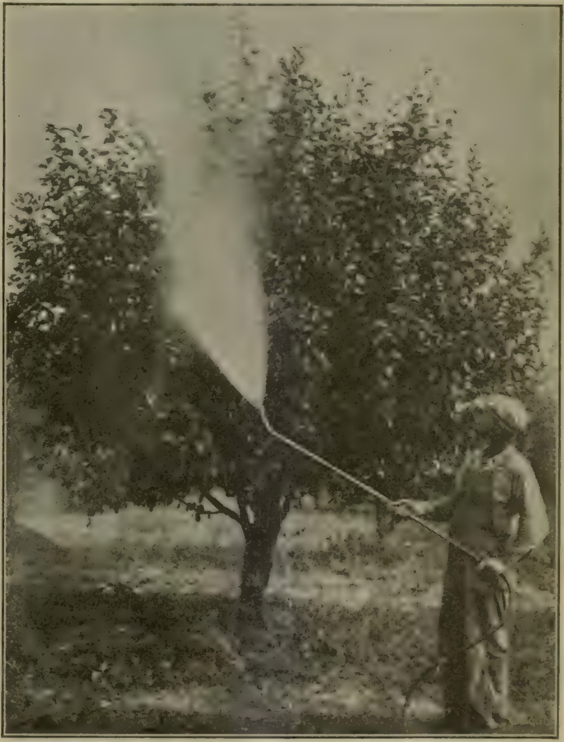

FIGURE 34.—Angle spray gun. This is a compromise between the short gun and the long spray rod. The spray may be adjusted from a very fine mist to a forceful, driving spray

With large acreages, water should be available at numerous points in the orchard in order to avoid excessive waste of time in travel between the filling station and the portion of the orchard where the spraying is in progress. If convenient filling points can not be provided, some growers haul water or the mixed spray liquid to the spray rigs in the field in order to conserve the time of the spray crews.

PRESSURE REGULATOR

The pressure regulator is a useful attachment. By its proper adjustment a uniform spray is obtained at the pressure desired.

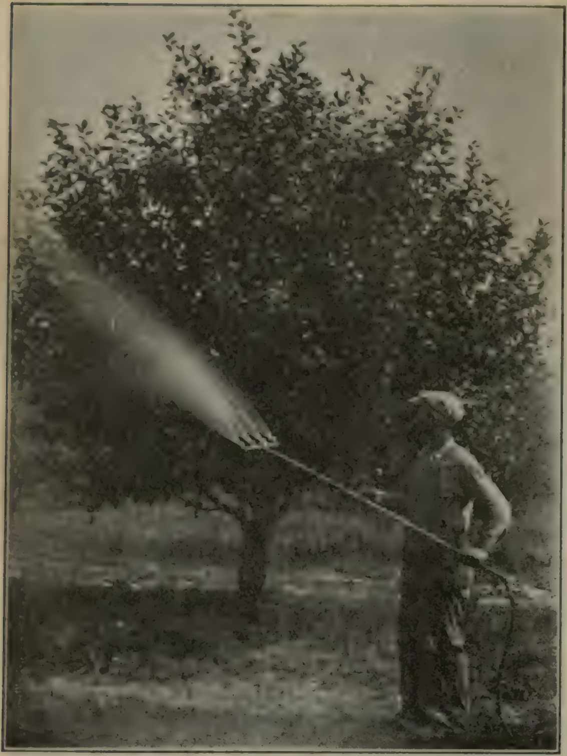

FIGURE 35.—Nozzle cluster gun, intermediate in type between the spray rod and spray gun. A fine mistlike spray is delivered with sufficient force to carry it to considerable distances

MISCELLANEOUS SPRAYING EQUIPMENT

The following accessories should be provided:

Scales. A good pair of scales should be used for weighing out the spray materials, unless the original packages contain the exact quantities needed. Guesswork is poor economy.

Galvanized buckets. These are useful for measuring liquid spray materials.

Strainer. Before a spray material enters the spray tank, it should first pass through a screen (fig. 36) to remove all of the coarse particles. The opening in the spray tank of a power outfit is usually provided with a removable brass screen.

Extra parts: Extra parts of the equipment most subject to wear or breakage should always be on hand. Failure to observe this precaution will frequently result in delays at critical spraying periods.

Tools: Tools specially made for the different parts of the spraying outfit are usually supplied by the manufacturer. Other standard tools, such as wrenches, screw drivers, and hammers, should also be carried in the tool box so that they may be available in case of need.

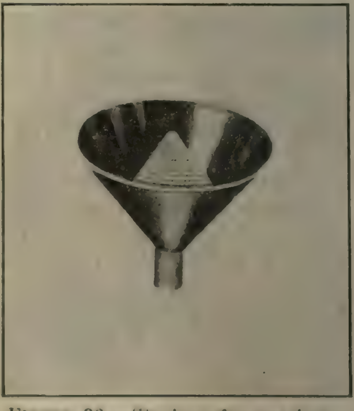

FIGURE 36.—Strainer for use in removing sediment from spray when it is being poured into the spray tank

STANDARD SPRAY MATERIALS AND THEIR COMBINATIONS FOR SUMMER SPRAYING

Orchards and vineyards are usually troubled with different classes of pests, as biting insects, sucking insects, and fungous diseases, each of which usually requires for its control a different kind of spray material. Fortunately it is often possible to combine the necessary materials for the simultaneous control of the pests, thus avoiding separate applications.

In Figure 37 are given the standard spray materials for chewing insects, sucking insects, and fungous diseases, and the way in which they may be combined. There are three main divisions according to the principal stomach poisons in use: (1) Lead arsenate; (2) calcium arsenate; and (3) Paris green. Each of these divisions is divided in accordance with the kind of fruit: Pome fruits, grape, and stone fruits. These, in turn, are subdivided into sections: (1) Chewing insects; (2) chewing and sucking insects; and (3) chewing insects, sucking insects, and fungous diseases. These are further divided, when a choice of spray material could be given. To make use of the diagram, the first consideration is the kind of fruit to be sprayed; next, the pests to be combated; and, finally, the choice of the spray materials. In selecting the spray materials the specific recommendations given elsewhere in this bulletin should be consulted.

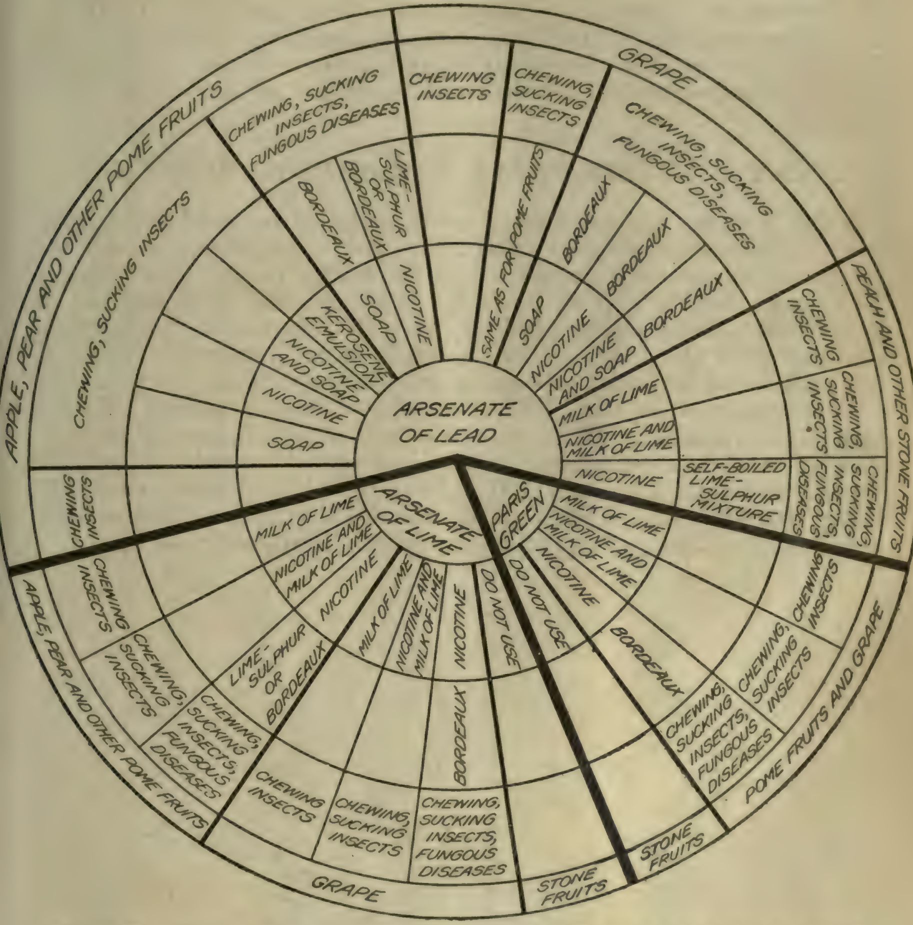

FIGURE 37.—Showing what sprays may be combined and plants which may be treated

If pome fruits, for example, are to be treated for chewing insects, lead arsenate, calcium arsenate, or Paris green may be used; but, as will be seen in the diagram, milk of lime should be added to the latter two. If stone fruits are to be sprayed for chewing insects nothing but lead arsenate combined with milk of lime should be employed. Again, suppose apple trees are infested with chewing and sucking insects and that lead arsenate is selected for the former, it will be observed that this arsenical may be combined with soap, or nicotine, or nicotine and soap, or kerosene emulsion. If apples are to be sprayed for both chewing and sucking insects and also fungous diseases, and calcium arsenate is to be used for the chewing insects, nicotine should be added to it, and lime-sulphur or Bordeaux mixture.

SPRAY DILUTION TABLE FOR READY REFERENCE

Table 3 shows the quantity of spray material required for a number of different quantities of spray. The strength for which the materials have been computed will be found in the first column. The figures at the top of the table represent the total number of gallons of diluted spray desired, and the figures in the vertical columns give the quantity of spray material required. Thus, if 150 gallons of lead arsenate spray in the proportion of 1 pound to 50 gallons is to be used, the table shows that 3 pounds of lead arsenate is required. If 25 gallons of self-boiled lime-sulphur mixture is needed, 4 pounds of stone lime and 4 pounds of sulphur should be used. Again, if 100 gallons of lubricating-oil emulsion, 3 per cent strength, is wanted and the stock mixture contains 66⅔ per cent of oil, 4.5 gallons of the stock emulsion should be used.

TABLE 3.—*Quantities of material or stock mixtures needed for making up various quantities of spray*

SPRAY MATERIAL AND USUAL DILUTION FOR TREES IN FOLIAGE

Material and strength	Quantity of material needed for the specified number of gallons of completed spray									
	200	150	100	50	25	20	15	10	5	1
Stomach poisons:										
Lead arsenate, 1 lb. to 50 galls.	4 lbs.	3 lbs.	2 lbs.	1 lb.	8 oz.	6.4 oz.	4.8 oz.	3.2 oz.	1.6 oz.	0.32 oz. or 3 rounded tp.
Lead arsenate (paste), 2 lbs. to 50 galls.	8 lbs.	6 lbs.	4 lbs.	2 lbs.	1 lb.	12.8 oz.	9.6 oz.	6.4 oz.	3.2 oz.	0.64 oz. or 1 rounded tp.
Calcium arsenate (powder), ¾ lb. to 50 galls.	3 lbs.	2.25 lbs.	1.5 lbs.	12 oz.	6 oz.	4.8 oz.	3.6 oz.	2.4 oz.	1.2 oz.	0.24 oz. or 2 rounded tp.
Paris green, 6 oz. to 50 galls.	1.5 lbs.	1.12 lbs.	12 oz.	6 oz.	3 oz.	2.4 oz.	1.8 oz.	1.2 oz.	0.6 oz.	0.12 oz. or 0.5 rounded tp.
Contact sprays:										
Nicotine sulphate (40 per cent nicotine), 1 to 800 = ½ pt. to 50 galls.	1 qt.	1.5 pts.	1 pt.	8 fl. oz.	4 fl. oz.	3.2 fl. oz.	2.4 fl. oz.	1.6 fl. oz.	0.8 fl. oz.	1 tp.
Nicotine sulphate (40 per cent nicotine), 1 to 1,066 = ⅜ pt. to 50 galls.	1.5 pts.	1.12 pts.	12 fl. oz.	6 fl. oz.	3 fl. oz.	2.4 fl. oz.	1.8 fl. oz.	1.2 fl. oz.	0.6 fl. oz.	0.75 tp.
Kerosene emulsion (66⅔ per cent), 10 per cent strength.	30 galls.	22.5 galls.	15 galls.	7.5 galls.	3.75 galls.	3 galls.	2.25 galls.	1.5 galls.	3 qts.	1.2 pts.
Fish-oil soap, 1 lb. to 4 galls.	50 lbs.	37.5 lbs.	2.5 lbs.	12.5 lbs.	6.25 lbs.	5 lbs.	3.75 lbs.	2.5 lbs.	1.25 lbs.	4 oz.
Fungicides:										
Lime-sulphur concentrate[1] [2] (33° Baumé) 1½ galls. to 50 galls.	6 galls.	4.5 galls.	3 galls.	1.5 galls.	3 qts.	2.4 qts.	1.8 qts.	1.2 qts.	0.6 qt.	4 fl. oz.
Bordeaux mixture (4–4–50); stone lime, copper sulphate, each.	16 lbs.	12 lbs.	8 lbs.	4 lbs.	2 lbs.	1.6 lbs.	1.2 lbs.	12.8 oz.	6.4 oz.	1.3 oz.
Self-boiled lime-sulphur mixture[1] (8–8–50); stone lime, sulphur, each.	32 lbs.	24 lbs.	16 lbs.	8 lbs.	4 lbs.	3.2 lbs.	2.4 lbs.	----	----	----

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[1] Also serves as a contact spray during the summer season for newly-hatched scale insects.

[2] For dilutions of lime-sulphur differing from 32° to 33° gravity, also for dilutions of 1–50 and 1¼–50 see Table 1 (p. 13).

Abbreviations: Oz. = ounce; lbs. = pound; fl. oz. = fluid ounce; pt. = pint; qt. = quart; galls. = gallon; tp. = teaspoonful. Weights: 16 ounces = 1 pound. Measures: 7 teaspoonfuls = 1 fluid ounce; 16 fluid ounces = 1 pint; 32 fluid ounces = 1 quart; 4 quarts = 1 gallon.

TABLE 3.—*Quantities of material or stock mixtures needed for making up various quantities of spray*—Continued

SPRAY MATERIAL AND USUAL DILUTION FOR DORMANT TREES

Material and strength	Quantity of material needed for the specified number of gallons of completed spray									
	200	150	100	50	25	20	15	10	5	1
Contact sprays:										
Lime-sulphur concentrate (33° Baumé), 1 gall. to 8 galls.	25 galls.	18.75 galls.	12.5 galls.	6.25 galls.	3.13 galls.	2.5 galls.	1.87 galls.	1.25 galls.	2.5 qts.	1 pt.
Lime-sulphur concentrate (33° Baumé), 1 gall. to 9.5 galls.	21 galls.	15.75 galls.	10.5 galls.	5.25 galls.	2.63 galls.	2.1 galls.	1.57 galls.	1.05 galls.	2 qts.	0.84 pt.
Lubricating-oil emulsion, 66⅔ per cent oil content, 3 per cent strength.[3]	9 galls.	6.75 galls.	4.5 galls.	2.25 galls.	1.13 galls.	3.6 qts.	2.7 qts.	1.8 qts.	0.9 qt.	5.8 fl. oz.
Kerosene emulsion (66⅔ per cent), 25 per cent strength.	75 galls.	56.5 galls.	37.5 galls.	19 galls.	9.5 galls.	7.5 galls.	5.7 galls.	3.8 galls.	1.9 galls.	3 pts.
Kerosene emulsion (66⅔ per cent), 20 per cent strength.	60 galls.	45 galls.	30 galls.	15 galls.	7.5 galls.	6 galls.	4.5 galls.	3 galls.	1.5 galls.	2.4 pts.
Fish-oil soap, 2 lbs. to 1 gall.	400 lbs.	300 lbs.	200 lbs.	100 lbs.	50 lbs.	40 lbs.	30 lbs.	20 lbs.	10 lbs.	2 lbs.

[3] For dilutions of oil emulsion having an oil content differing from 66⅔ per cent; also for concentrations of 1, 2, and 4 per cent see Table 2 (p. 21).

Abbreviations: See preceding page.

SOME IMPORTANT INSECTS AND THEIR TREATMENT

APPLE INSECTS

INSECTS CONTROLLED BY WINTER OR DORMANT TREE SPRAYING

SAN JOSE SCALE

The San Jose scale (*Aspidiotus perniciosus* Comst.) infests the trunk, limbs, and branches of most fruit trees, apples, pears, peaches, plums, etc. The mature scale (fig. 38) is about the size of a pinhead, circular in outline, grayish in color, with a nipplelike prominence in the center. The bark of badly infested trees is ash gray and when cut into shows a reddish discoloration. Unless given effective treatment, heavily infested young trees are usually killed in two or three seasons. The vitality of older trees is quickly impaired, and eventually they are destroyed by its attack. The San Jose scale is usually controlled by one thorough spraying of the trees each year with one of the petroleum-oil sprays (p. 18) or with lime-sulphur solution (p. 11). Fish-oil soap washes may be employed (p. 23), and these are convenient where only a few trees are to be treated. Badly infested trees should be sprayed in the fall as soon as the leaves are off, and again the following spring before the buds open. Ordinarily one treatment each year, preferably in the spring, will be sufficient, although thorough work is necessary to destroy the insect so that there will be no spotting of the fruit.

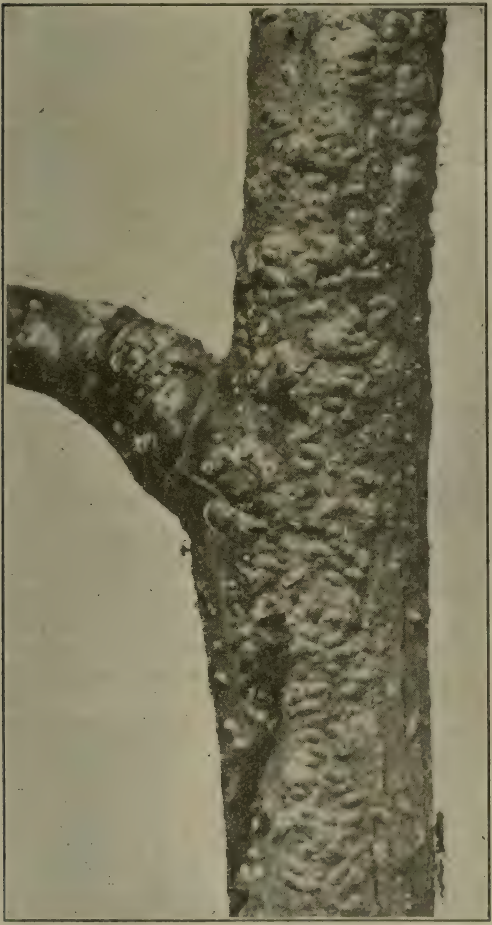

FIGURE 38.—San Jose scale. Five times natural size

OYSTER-SHELL SCALE

The oyster-shell scale (*Lepidosaphes ulmi* L.) is readily recognized from the resemblance of its scale or covering to a long narrow oyster shell, as shown in Figure 39. The female scale is about one-eighth

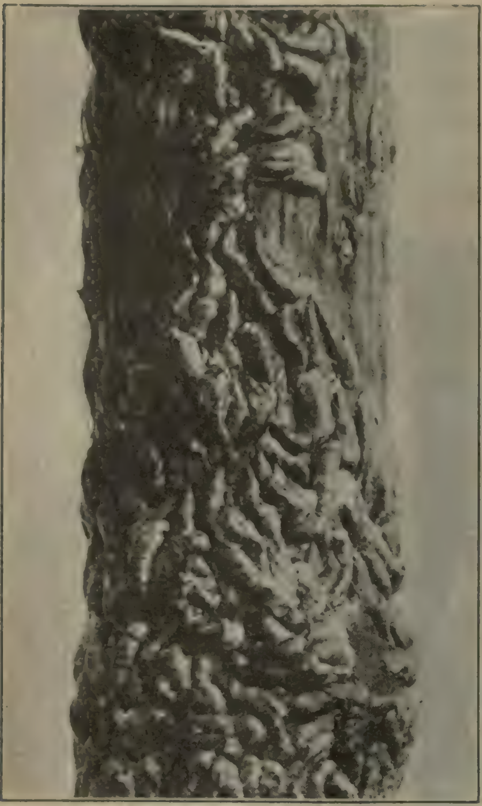

FIGURE 39.—Oyster-shell scale. 2½ times natural size

of an inch long, brown to dark brown, though sometimes grayish in appearance. To completely kill out this species during the dormant season it is necessary to use from 6 to 8 per cent of oil. The oyster-shell scale usually multiplies rather slowly, however, and the sprays used for the San Jose scale will ordinarily keep this scale insect in check. When infesting apple, pear, etc., it may also be treated with one of the summer oils or with lime-sulphur at summer strength when the young are hatching in the spring. For any locality the hatching will usually occur during the period of one to three weeks following the blooming of the apple.

SCURFY SCALE

Although seldom very injurious to orchard trees, the scurfy scale (*Chionaspis furfura* Fitch) (fig. 40) is the subject of frequent inquiry from fruit growers and others. The dormant treatment recommended for the San Jose scale will aid much in keeping this species in check. It may also be treated with dilute scale washes as the young are hatching in the spring, as just described for the oyster-shell scale.

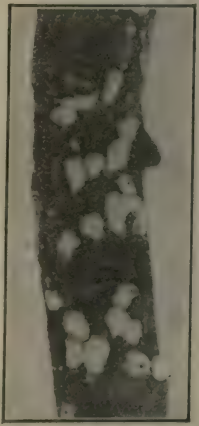

FIGURE 40.—Scurfy scale. Twice natural size

PEAR LEAF BLISTER MITE

The very minute creature known as the pear leaf blister mite (*Eriophyes pyri* Pgst.) (see under Pear Insects, p. 73) has become in recent years an important apple pest in some localities. It is best controlled by the dormant lime-sulphur treatments recommended for the control of the San Jose scale.

EUROPEAN RED MITE

In recent years the European red mite (*Paratetranychus pilosus* C. and F.) has done considerable damage in a number of fruit districts, the tiny mites causing a bronzing and weakening of the foliage which in heavy infestations results in more or less defoliation. These creatures winter in the form of tiny red eggs on the twigs and smaller branches of the trees (fig. 41), where they may be destroyed by thorough applications of lubricating-oil emulsion at from 3 to 4 per cent strength, or by miscible oils at the dilution recommended by the manufacturer. The applications have their greatest degree of effectiveness if they are made in the spring just

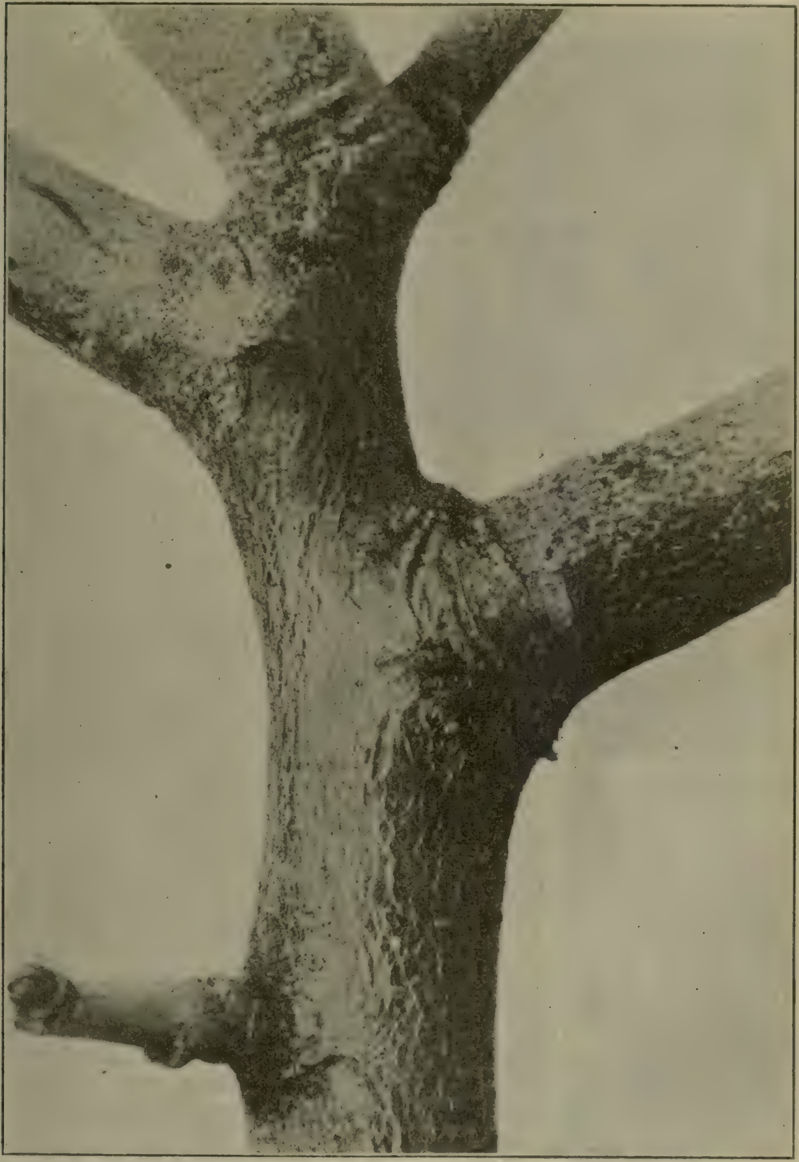

FIGURE 41.—Winter eggs of the European red mite. Magnified 2½ times

as the buds are swelling rather than in the fall. Lime-sulphur is not very effective as a dormant spray for the eggs of the mite, although during the summer it has considerable value against the active stages.

APPLE APHIDS

Three kinds of aphids in particular are important pests of apple foliage, namely, the rosy apple aphid (*Anuraphis roseus* Baker), the green apple aphid (*Aphis pomi* DeG.), and the apple-grain aphid (*Rhopalosiphum prunifoliae* Fitch). These are small greenish or pink plant lice which curl the leaves. The rosy apple aphid also distorts the fruit. These insects winter on the apple trees in the egg stage, the young hatching and congregating on the buds when the latter swell and break open. (Fig. 42.) Thorough spraying at this time with nicotine sulphate (40 per cent nicotine) usually prevents serious injury later in the season. Three-fourths of a pint per 100 gallons of spray should be used. If the dormant-tree treatment for the San Jose scale with lime-sulphur solution is delayed until the buds are breaking, the scale and aphid treatment may be combined in what is often referred to as the delayed dormant application (pp. 71–72).

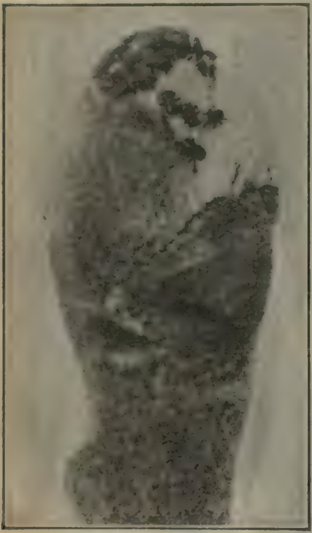
FIGURE 42.—Aphids clustered on expanding apple bud. Proper time to start the delayed dormant spray. This application should be completed before the leaves have pushed out one-half inch. About five times natural size.

The various oil sprays, if applied during the delayed dormant period, have more or less value in the control of the apple aphids, but are much less dependable than the lime-sulphur-nicotine combination and under some conditions, particularly in the Northwest, are likely to cause injury to the unfolding buds. The addition of nicotine to oil sprays improves their effectiveness in the control of the apple aphids.

INSECTS CONTROLLED BY SUMMER SPRAYING AND OTHER MEASURES

APPLE WORM, OR CODLING MOTH

The dirty white or pinkish caterpillar which feeds within the apple (fig. 43) is known as the apple worm, and the adult insect, into which it develops, as the codling moth (*Carpocapsa pomonella* L.). The number of broods of larvae each year ranges from one to three or four, according to latitude and altitude. The insect is usually well controlled by the timely use of arsenical sprays, the number of applications varying with different sections. A spray schedule for apple orchards is given on page 71. In controlling severe infestations, spraying must be supplemented by banding, orchard sanitation, and other auxiliary measures.

LESSER APPLE WORM

The lesser apple worm (*Laspeyresia prunivora* Walsh) infests the fruit much as does the codling moth, but the burrows are usually not so deep, and the larva mines more under the skin in the calyx basin or on the sides of the fruit. The larva is pinkish and smaller than that of the codling moth. The treatments recommended for the codling moth will be effective in controlling the lesser apple worm.

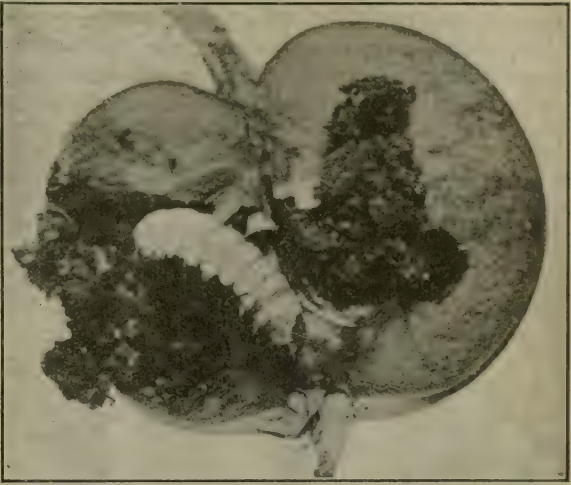

FIGURE 43.—Codling moth or apple worm and its injury to apple. Twice natural size

PLUM CURCULIO

The plum curculio (*Conotrachelus nenuphar* Herbst) is one of the causes of knotty, deformed apples. (Fig. 44.) The small snout beetles puncture the young fruit in the early spring while feeding and laying their eggs, causing much of the fruit to fall or to become misshapen as it grows, thereby destroying or lessening its market value. In addition, the beetles, while feeding in the fall, excavate small holes or cavities in the ripening fruit, which favor its decay by fungi or other causes.

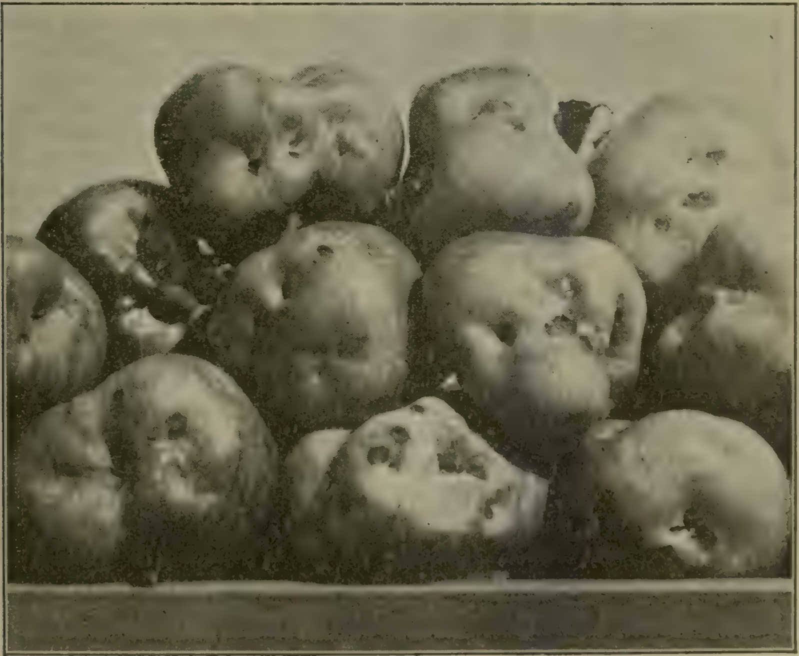

FIGURE 44.—Apples deformed by plum curculio

The second and third spray applications recommended on pages 72 and 73 will aid much in reducing curculio injury to apples.

In the case of severe infestations special applications of spray in addition to those recommended in the regular schedule (p. 71) are needed during a period of about four weeks following the fall of the petals, when the curculios are most actively feeding and laying eggs. Some spray schedules recommend two applications 7 and 17 days after the calyx spray, whereas others suggest a single application 10 days after the calyx spray. In the case of orchards in sod, or more or less grown up in, or surrounded by, weeds or brush, spraying is not fully adequate, and these conditions should be corrected if possible.

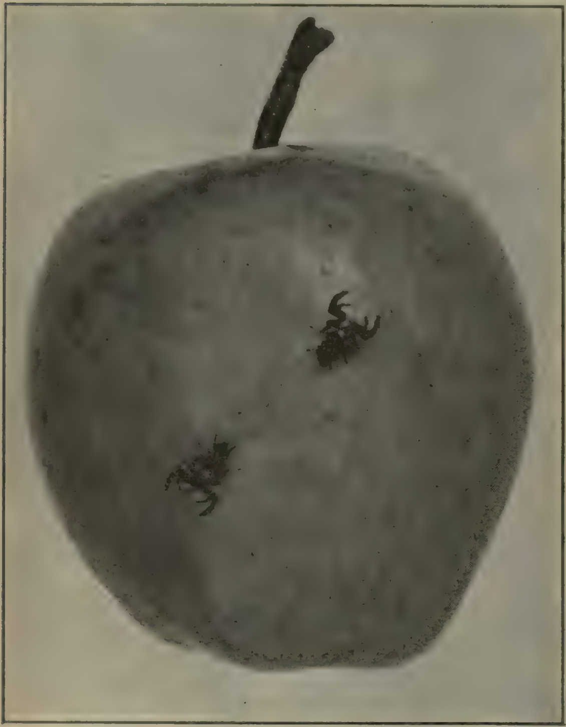
FIGURE 45.—Apple maggot. Adult flies resting on surface of apple. Slightly enlarged

APPLE MAGGOT

The apple maggot (*Rhagoletis pomonella* Walsh), also known as the railroad worm, makes discolored patches or winding burrows here and there in the flesh of the apple, and several larvae in a fruit usually will reduce the pulp to a slimy brownish mass. The insect is more or less prevalent throughout the Northeastern States. It prefers sweet and subacid varieties, especially those which ripen in late summer or early fall. The apple maggot may be controlled by keeping the foliage and fruit covered during July with a poison, such as lead arsenate, which destroys the flies (fig. 45) before egg laying begins to any extent. In attempting to control the apple maggot, it is essential to spray all infested trees. The presence of near-by sources of infestation often neutralizes any benefit which might otherwise have resulted from the application of lead arsenate. In the home orchard and elsewhere care should be taken to gather up promptly and destroy wormy, fallen fruit.

The use of lead arsenate on summer and early fall varieties of apples may result in excessive residue, necessitating its removal before the fruit is placed on the market.

APPLE RED BUGS

The sucking insects known as apple red bugs (*Lygidea mendax* Reuter and *Heterocordylus malinus* Reuter) are occasionally injurious in New York, Pennsylvania, Connecticut, and elsewhere. They puncture the little fruits early in the season, causing them to fall or become pitted and deformed. The use of nicotine sulphate (40 per cent nicotine), 1 pint to 100 gallons of spray added to one or more of the early season sprays, will give the best control. The more common of the two species usually hatches just as the apple comes into full bloom, and the calyx application comes at the right time for the control of this species. The other form hatches a little earlier, and for this one nicotine should be added to the preblossom, or pink, spray. The grower should determine the time when these bugs appear in his section, and add nicotine only to the application which coincides with their presence. A thorough driving spray is needed for the control of this pest, since the bugs are very active and dodge the spray whenever possible. (See Spraying Schedule, p. 71.)

EYE-SPOTTED BUD MOTH

The caterpillars of the eye-spotted bud moth (*Spilonota ocellana* Schiff.) attack the opening buds of the apple in the spring, and the species is particularly destructive throughout the Northern States, extending west to the Pacific coast. The dark-brown caterpillars hibernate about half grown in little cases around the buds, and as the leaves expand in the spring these are folded together by threads of silk and the caterpillars feed within them. Injured leaves often turn brown, and if the caterpillars are abundant their work is quite conspicuous. During late summer the young larvae of the new brood eat small holes in the skin of the apples, causing serious blemishes.

The usual spray schedule, which calls for the application of lead arsenate in the preblossom and calyx sprays, normally keeps the bud moth under control. In severe outbreaks, which occur locally at intervals, more drastic measures are needed. The New York experiment station at Geneva has recently reported good control from the use of strong nicotine sprays as nicotine sulphate (40 per cent nicotine) 1–400 applied during the delayed dormant period. Thorough spraying with lead arsenate during late July, special care being taken to coat the under surfaces of the leaves, is also of value in control.

CANKERWORMS

The spring cankerworm (*Paleacrita vernata* Peck) and the fall cankerworm (*Alsophila pometaria* Harris) are slender measuring worms, about 1 inch long when full grown, that feed upon the foliage of various fruit and other trees, but especially the apple and elm. (Fig. 46.) The leaves are attacked shortly after they put out in the spring and may be quickly devoured, leaving the trees brown as if swept by fire. Orchards well sprayed, as for the codling moth, suffer little. Injury to young orchards can be stopped by spraying promptly with lead arsenate upon first signs of injury. Cultivation of orchards during early summer destroys many pupae of the spring cankerworm in the ground. Large apple and shade trees may be protected by using bands of sticky substances, cotton batting, etc., around the trunk (p. 39.) For the fall cankerworm these bands should be in place in October and for the spring form some four or five weeks before the buds are due to open.

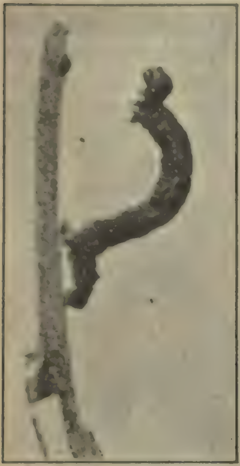
FIGURE 46.—Spring cankerworm. About twice natural size

EASTERN TENT CATERPILLAR

In the spring the eastern tent caterpillars (*Malacosoma americana* Fab.) make their unsightly nests, or tents, in trees along the roadsides, streams, neglected orchards, etc. (Fig. 47.) The wild cherry is their favorite food, though numerous other trees are attacked when the caterpillars are abundant. They are rarely of much importance in well-sprayed orchards. The egg masses on the twigs should be searched for and destroyed when the trees are leafless, and in the spring the nests should be torn out and the caterpillars killed. Rags saturated with kerosene on the end of a pole may be used to destroy caterpillars in their nests in the higher parts of the trees.

APPLE APHIDS

Plant lice, or aphids, which were discussed on page 66, often become abundant on the apple trees during spring and summer. The delayed dormant treatment already recommended is the most effective control measure, but if the insects continue abundant when the first scab treatment is due, nicotine sulphate (40 per cent nicotine), three-fourths of a pint to 100 gallons of spray, may be added to the dilute lime-sulphur solution. It may be advisable to use the nicotine in the first codling-moth treatment also, if the aphids continue destructive, though it will serve merely to check them. The green apple aphid (*Aphis pomi* DeG.) often becomes abundant during summer, especially on young trees, but satisfactory control is difficult on account of the curled condition of the leaves.

ROUNDHEADED APPLE-TREE BORER

The roundheaded apple-tree borer (*Saperda candida* Fab.) infests the apple, quince, pear, and numerous wild plants, especially the serviceberry, mountain-ash, and crab. Trees are attacked at or near the base, the larvae feeding the first season under the bark and during the second and third years entering the wood. A few borers in a young tree may kill it, and older trees are always greatly injured by them. (Fig. 48.)

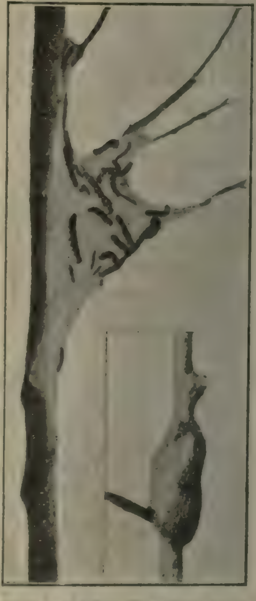
FIGURE 47.—Eastern tent caterpillars and nest; egg mass on twig on the right

Fruit trees subject to attack should be wormed each year, care being taken not to injure the bark and wood more than necessary (p. 32). The beetles are laying eggs during May and June and less actively until September. They may be largely deterred from egg laying by coating the trunk of the trees, from 3 to 4 inches below the ground to about 1 foot above, with paint (p. 34). It will often be practicable to remove from the neighborhood of orchards wild host plants, such as serviceberry trees and mountain-ash.

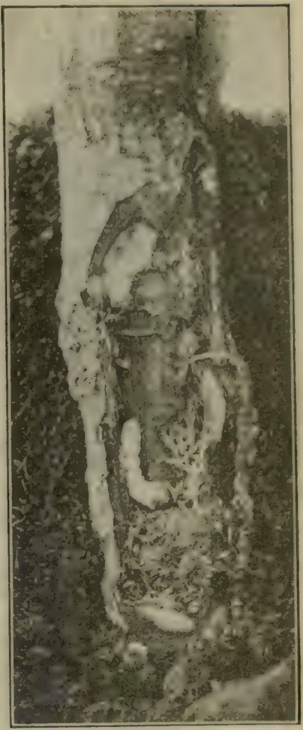

FIGURE 48.—Roundheaded apple-tree borer and its injury to young apple tree (the bark has been removed to show the borer in its burrow). About natural size

WOOLLY APPLE APHID

The woolly apple aphid (*Eriosoma lanigerum* Hausm.) occurs on the limbs and twigs of apple trees as bluish-white colonies, or patches, but is more injurious to the roots, which become knotty and deformed, thereby stunting the trees and at times resulting in their death, especially during periods of drought. (Fig. 49.) Trees found to be suffering from the woolly aphid at the roots should be given especial care as to fertilization and cultivation, to enable them to grow in spite of the presence of the insect. Lack of growth due to unfavorable soil conditions is often attributed to this insect. Colonies of aphids on limbs and branches may be controlled with the usual contact sprays, applied liberally and under strong pressure.

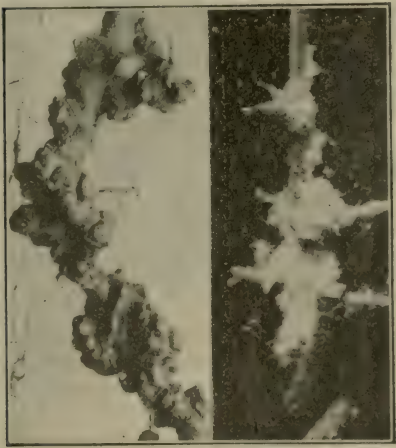

FIGURE 49.—Woolly apple aphid: Injury to root on left, and colony of aphids on twig on right

APPLE-SPRAYING SCHEDULE

DORMANT-TREE SPRAYING

During the period when the trees are dormant much stronger sprays may be used than at other times, and for this reason dormant-tree spraying is especially advisable for the treatment of scale insects, the blister mite, etc. Applications may be made in the fall after the leaves have dropped, during warm days in the winter, or in the spring before the new growth begins to appear. Where aphids are troublesome it is often practicable to delay the San Jose scale treatment until just as the buds are breaking (fig. 42), and by adding nicotine effect a combination treatment for both the scale and aphids. For this purpose the combination lime-sulphur-nicotine mixture is more effective than the oil-nicotine combination.

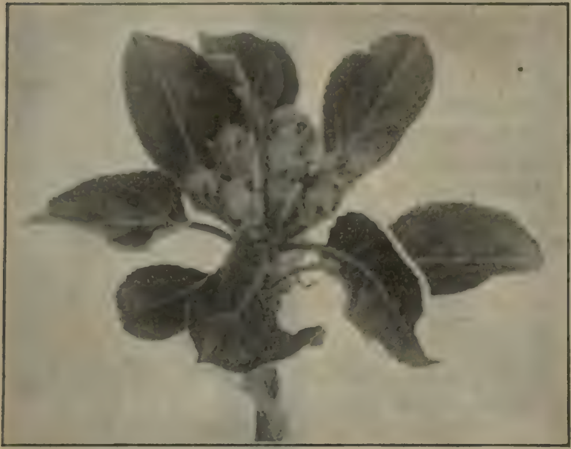

FIGURE 50.—Cluster of apple blossoms in the pink stage, when first summer treatment should be made

SUMMER SPRAYING

First application.[12]—Use concentrated lime-sulphur solution (33° Baumé) in the proportion of 1¼ to 1½ gallons to 50 gallons of spray plus 1 pound of lead arsenate just before the blossoms open. (Fig. 50.) This application is for apple scab, and for chewing insects, such as the cankerworms, the bud moth, case bearers, and the tent caterpillar, and has a little value against the plum curculio. Add about one-half pint of nicotine sulphate (40 per cent nicotine) if apple red bugs are troublesome and if apple aphids are much in evidence.

Second application.—Use the same spray[13] as in the first application as soon as the blossoms have fallen. (Fig. 51.) This, known also as the calyx spray, is for the above-mentioned troubles as well as for the codling moth and leaf spot. It is the most important application for the codling moth and is also important in the control of apple scab. In spraying for the codling moth at this time the aim is to drive a quantity of the poison into the calyx end of each little apple, and to accomplish this, painstaking work is necessary. Failure to do thorough spraying at this time for the codling moth can not be remedied by subsequent applications.

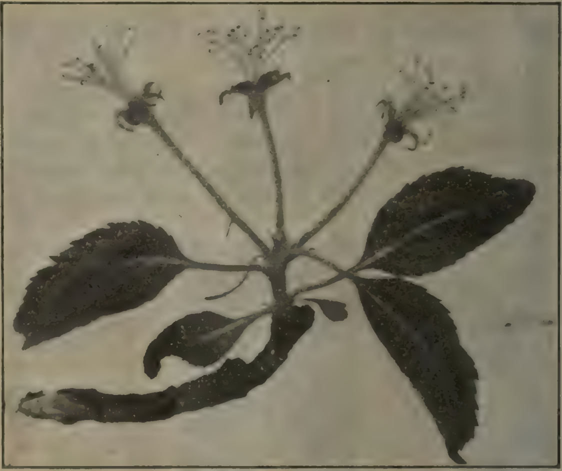

FIGURE 51.—Apple blossoms from which petals have just fallen; the right time to apply the calyx spray for the codling moth

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[12] In certain northern districts, delayed-dormant and prepink sprays are frequently applied earlier in the season against apple scab. See Farmers' Bulletin 1479.

[13] Many orchardists, especially in localities of codling-moth abundance, use 1½ pounds of lead arsenate to 50 gallons of spray in all summer applications.

Third application.—Use the same spray three to four weeks after the blossoms have fallen. This is the second treatment for the codling moth and leaf spot and gives further protection against apple scab and certain insects. The exact timing of this application varies in different localities. In orchards in which blotch [14] has been prevalent this application should be made not less than three weeks after the blossoms have fallen. Where this disease has been severe, Bordeaux mixture (3–4–50, p. 27) should be substituted for the lime-sulphur solution.

Fourth application.—Use Bordeaux mixture (4–4–50) and lead arsenate (1–50) 9 or 10 weeks after the petals have fallen. This is the first application for the second brood of the codling moth and for bitter rot. In orchards in which bitter rot has been a serious disease this application should be advanced about one week.

Fifth application.—Use Bordeaux mixture from two to three weeks after the fourth application. This is the second application for bitter rot; and lead arsenate should be added as a protection against late-appearing larvae of the codling moth.

Sixth application.—Use Bordeaux mixture again two or three weeks after the fifth treatment has been applied. This is the third application for bitter rot and is ordinarily sufficient to carry the fruit through, but on specially susceptible varieties in bitter-rot sections a treatment to be made two weeks later may be found necessary.

NOTE.—In severe cases of bitter rot a seventh application may be necessary, and in severe cases of blotch an extra treatment midway between the third and fourth applications is sometimes required.

In the more northern apple-growing sections the first four applications, during ordinary seasons, will be sufficient to protect the fruit from the various insects and diseases mentioned, but if the curculio is unusually destructive, one or two applications of lead arsenate, 1½ to 2 pounds in 50 gallons, should be made between the calyx spray and the third application. In severe codling moth infestations one or two additional cover sprays are applied for the first-brood worms at 10-day or 2-week intervals after the third application. In the more central States, where bitter rot and blotch are prevalent, the fifth and six applications will be necessary. In the case of summer apples only the first three applications are needed.

PEAR INSECTS

CONTROLLED BY WINTER OR DORMANT TREE SPRAYING

SAN JOSE SCALE

The San Jose scale infests pears (except Kieffer and LeConte varieties) and should be treated as described for the San Jose scale on apple (p. 63).

PEAR LEAF BLISTER MITE

The pear leaf blister mite is usually present wherever pears are grown and frequently requires treatment on pears as well as on apples. The mites winter behind the bud scales and attack the unfolding leaves and young fruit in the spring, causing reddish or greenish blisterlike spots which later in the season become brown

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[14] For more specific information on control of blotch, see Farmers' Bulletin 1479.

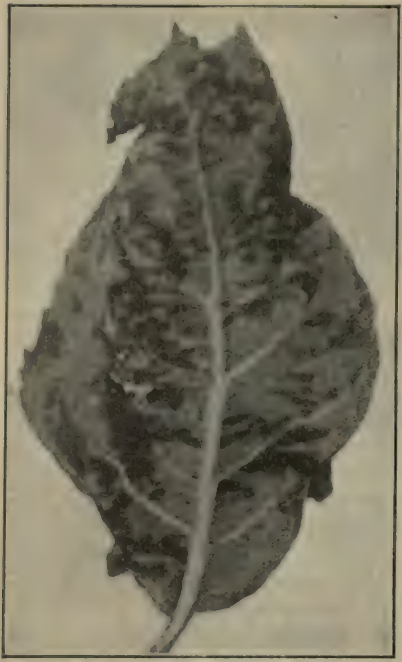

FIGURE 52.—Pear-leaf blister mite injury to apple leaf

and dead. (Fig. 52.) If the attack is severe, the foliage may fall, stunting the fruit and in extreme cases causing it to shed. The lime-sulphur and oil sprays used for the San Jose scale (pp. 11 and 16) keep the blister mite in check, lime-sulphur being considered more completely effective than the oil sprays.

CONTROLLED BY SUMMER SPRAYING AND OTHER MEASURES

CODLING MOTH

The apple worm also attacks the pear, in some localities quite seriously. It should be treated as recommended for the apple, the second, third, and fourth applications of the apple spraying schedule usually being sufficient.

PEAR SLUG

The pear slug (*Eriocampoides limacina* Retz.) skeletonizes the leaves of the pear, cherry, and to some extent the plum. The slimy snail-like larvae (fig. 53) appear on the trees in May or June, according to latitude. A second brood may be in evidence about midsummer. The pest is easily controlled by arsenicals sprayed or dusted on the foliage or by the use of contact sprays.

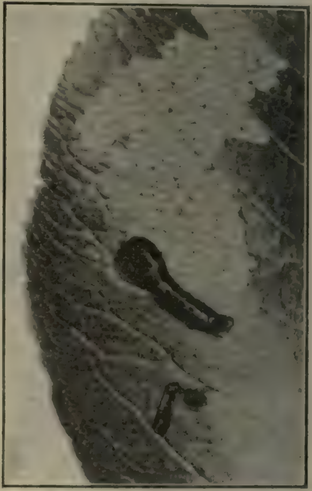

FIGURE 53.—Pear slug and its injury. About twice natural size

PEAR PSYLLA

The pear psylla (*Psyllia pyricola* Först.) is very troublesome in some regions, and careful and persistent work is required to keep it under control. The insects suck out the sap from the foliage and leaf stalks, causing the leaves to turn yellow and later brown, and many of these fall prematurely, with consequent injury to the fruit. Infested pears are usually sooty in appearance, as a result of the growth of a black fungus on the sticky excrement or honeydew voided by the insects. Adults hibernate in cracks in the bark of the trunk and limbs, under bark scales, or under trash on the ground in and near the orchard, and migrate to the trees with the very first warm days of early spring. Applications of 3 per cent lubricating-

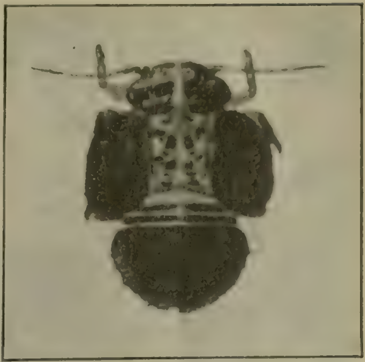

Figure 54.—Pear psylla: Immature stage. About 25 times natural size

oil emulsion at this time have given very satisfactory results. Many of the adult flies are killed, and the film of oil on the bark appears to have a great deal of residual value, reducing the number of eggs laid and killing a high percentage of the young psyllas that hatch. In Ontario, the cold-mixed Bordeaux-oil emulsion has proved the most satisfactory, and the heavier oils, having a viscosity of 150 to 200 seconds, seem to be the most effective. Nymphs of the first brood (fig. 54) congregate mostly in the axils of the young leaves and fruit and may be treated with a nicotine-soap spray, applied just after the blossoms have fallen, lead arsenate being added for the codling moth.

PEAR THRIPS

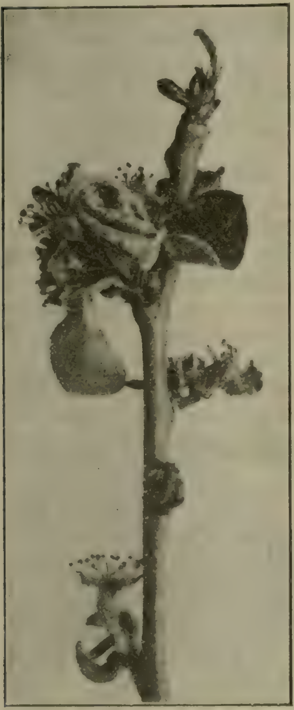

Figure 55.—Pear thrips: Injury to blossoms and foliage of pear

The adult pear thrips (*Taeniothrips inconsequens* Uzel) come from the ground in the spring as the bud scales are spreading, and owing to their minute size are able to work their way within the scales, where they feed upon the tender tissues of leaf and flower buds. Fruits like the pear and prune, which bear the blossoms in clusters, suffer worst, and when the insects are abundant the crop may be literally destroyed in the bud. (Fig. 55.) Fruit from blossoms attacked, but which escaped destruction, is likely to be deformed and scabby and of lessened market value. The pear thrips has caused large losses on the Pacific coast and more recently has become established in the Hudson River Valley, in Maryland, and elsewhere in the East. It is controlled by spraying with nicotine and soap (p. 24), or with a mixture of nicotine and an oil spray, when the buds first begin to open, and again after falling of the blossoms. A second bud application is desirable when the insects are very abundant. Best results follow the use of a coarse spray under high pressure directed from above into the opening buds. The oil spray used, especially for the petal-fall spray, should be one which has been found safe on pear foliage.

QUINCE INSECTS

With two exceptions, the more important insects attacking the quince were discussed under apple (p. 63).

QUINCE CURCULIO

In some localities the quince curculio (*Conotrachelus crataegi* Walsh) is by far the most important insect enemy of quince. Its attack causes the fruit to become wormy and knotty, and in some sections the injuries which it causes may result in a loss of over 90 per cent of the crop. It is controlled with difficulty. Thorough spraying with a strong spray of lead arsenate when the beetles first appear and repeating the application about a week later are of value. Injury may be reduced also by capturing the beetles with curculio catchers or jarring them onto sheets placed on the ground or held under the trees (p. 36).

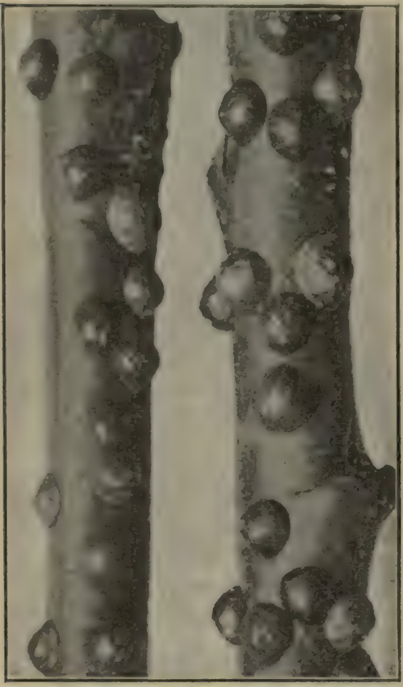

FIGURE 56.—Terrapin scale on peach twigs. About five times natural size

ORIENTAL FRUIT MOTH

The oriental fruit moth (see p. 79) is one of the most serious pests attacking the quince.

ROUNDHEADED APPLE-TREE BORER

The roundheaded apple-tree borer is often more injurious to quince than to apple. (See p. 70.)

PEACH INSECTS[15]

CONTROLLED BY WINTER OR DORMANT TREE SPRAYING

SAN JOSE SCALE

The San Jose scale requires treatment on peach, and either the winter strength lime-sulphur solution or the oil sprays may be used. (See Spraying Schedule, p. 80.)

TERRAPIN SCALE

In the middle Appalachian area the terrapin scale (*Lecanium nigrofasciatum* Perg.) (fig. 56) is sometimes very troublesome on peach and plum. The honeydew or excrement voided by the scales furnishes a medium for the growth of a black mold which covers the foliage and fruit, lessening the market value of the latter. Lime-sulphur sprays are not effective against this pest, and a 4 per cent lubricating-oil emulsion or a miscible oil (p. 22) should be applied in the spring just as the buds begin to swell.

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[15] The insects attacking the peach in the South are discussed in greater detail in Farmers' Bulletin 1557, Insects Attacking the Peach in the South and How to Control Them. This bulletin may be obtained free from the United States Department of Agriculture.

PEACH TWIG BORER

The peach twig borer (*Anarsia lineatella* Zell.) tunnels into the tender shoots of the peach (fig. 57) in the spring and later attacks the fruit. Fruit injury is especially common in California and other Western States. The insect winters as a very small larva in burrows in the bark, often in the crotches of the limbs, where it may be destroyed by spraying the trees during the dormant period with a winter-strength oil spray (p. 16). Lime-sulphur solution, as used for the San Jose scale (see Spraying Schedule, p. 80) is effective if applied as the buds begin to swell in the spring.

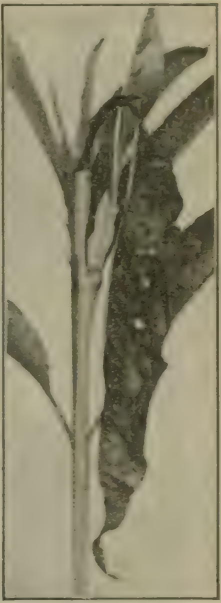

FIGURE 57.—Injury to peach shoot in the spring by the peach twig borer

CONTROLLED BY SUMMER SPRAYING OR OTHER MEASURES

PLUM CURCULIO

The plum curculio punctures the fruit for egg-laying and feeding purposes, causing it to fall or become knotty or distorted. (Fig. 58.) It is best controlled by spraying with lead arsenate, with the use of supplementary measures in severe infestations. Peach growers should follow the peach-spraying schedules given on pages 80 and 81, thus controlling also the peach scab and brown rot. These three are the most important causes of injury to the fruit, which are preventable by spraying.

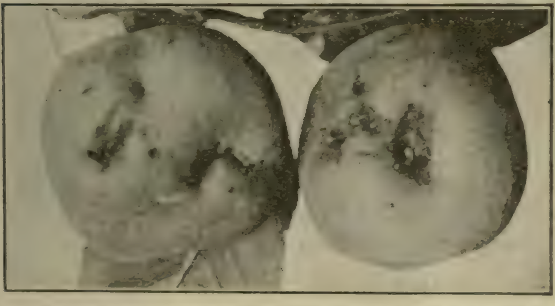

FIGURE 58.—Injury by plum curculio to peaches

PEACH BORER

The peach borer (*Synanthedon exitiosa* Say) attacks the tree at or below the ground, eating out patches or burrows in the inner bark. (Fig. 59.) Its presence is usually indicated by the exudation from the crown of a mass of gum more or less mixed with dirt and frass. It is a very serious enemy of the peach and to a less extent of other stone fruits, and in most districts it must be controlled to prevent the destruction of the trees. The application of paradichlorobenzene to the soil about the base of each tree, as described in Farmers' Bulletin 1246, The Peach Borer: How to Prevent or Lessen Its Ravages; the Paradichlorobenzene Treatment, gives satisfactory control for the species, but is not always safe on trees younger than 4 years. This chemical should be applied in a ring from 1 to 2 inches from the tree at the ground level, using from three-fourths to 1 ounce per tree, and covered with several inches of soil, well packed down. Paradichlorobenzene should be used during September in northern sections, and in the first half of October in the more southern sections. As a precaution against injury, the material should be removed after an exposure of from four to six weeks. If the chemical treatment is not employed, careful worming (p. 32) in the spring and fall should be practiced. A related species (*Synanthedon opalescens* Hy. Edw.) occurs on the Pacific coast.

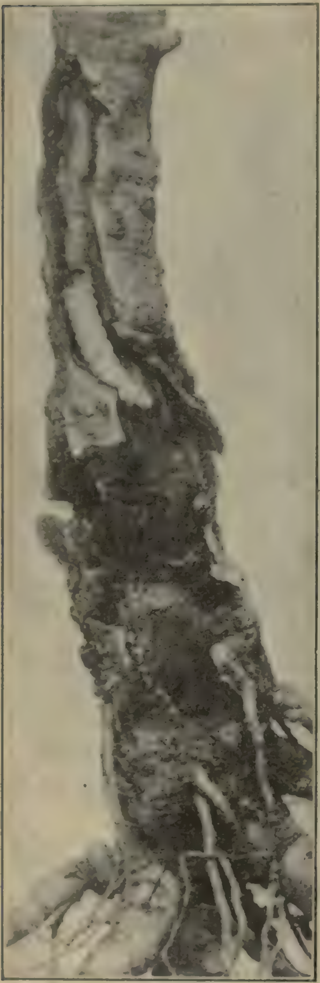
FIGURE 59.—Full-grown peach borer and its work on young peach tree. About two-thirds natural size

LESSER PEACH BORER

The lesser peach borer (*Synanthedon pictipes* Grote and Robinson) affects principally the trunk and branches of the peach, plum, and cherry. Injury to the bark, as from the effects of freezing, barking during cultivation, careless pruning, etc., open the way for its attack. This insect may be controlled by a method recently developed by the Bureau of Entomology. This control measure consists of painting the infested area with a solution of 1 pound of paradichlorobenzene in 2 quarts of cottonseed oil. The applications should be made in fairly warm weather, with average daily temperatures of 70° F. or higher. The treatment should be restricted to the infested areas, since the paradichlorobenzene-cottonseed oil mixture is sometimes injurious to the smooth bark portions of the tree, especially the smaller branches. The conditions favoring attack by the borers—the presence of long stubs left in pruning, and injuries to the bark on the trunk and limbs—should be avoided so far as possible.

FRUIT-TREE BARK BEETLE

The fruit-tree bark beetle (*Scolytus rugulosus* Ratz.), also called the shot-hole borer, and several closely allied species, attack most fruit trees as well as related wild plants. The larvae of the bark beetles tunnel just underneath the bark, feeding on the cambium. In emerging, the adults make tiny round holes in the bark, and in stone fruits the injury is usually indicated by the exudation of gum, often copious. (Fig. 60.)

The beetles prefer sickly or diseased trees, or those in a weakened condition from any cause. Such trees when once attacked may be quickly destroyed, and the beetles on account of their abundance are thus often thought to be the real cause of the trouble. Injury is best avoided by maintaining trees in a vigorous growing condition, by cultivation, fertilization, pruning, etc. Trees recently attacked may often be saved by severe pruning and fertilization with a nitrogenous fertilizer. Thorough coating of the trunk or branches with heavy whitewash (p. 35) is desirable, as this interferes with the activities of the beetles. Trees or branches which are so heavily infested that recovery is unlikely should be removed and destroyed to prevent their serving as centers of infestation.

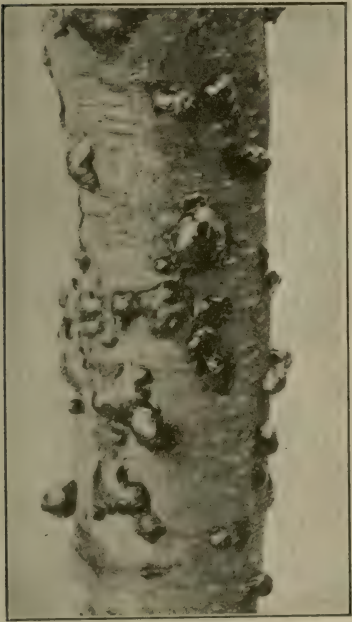

FIGURE 60.—Exudations of gum from peach following attack by the fruit-tree bark beetle

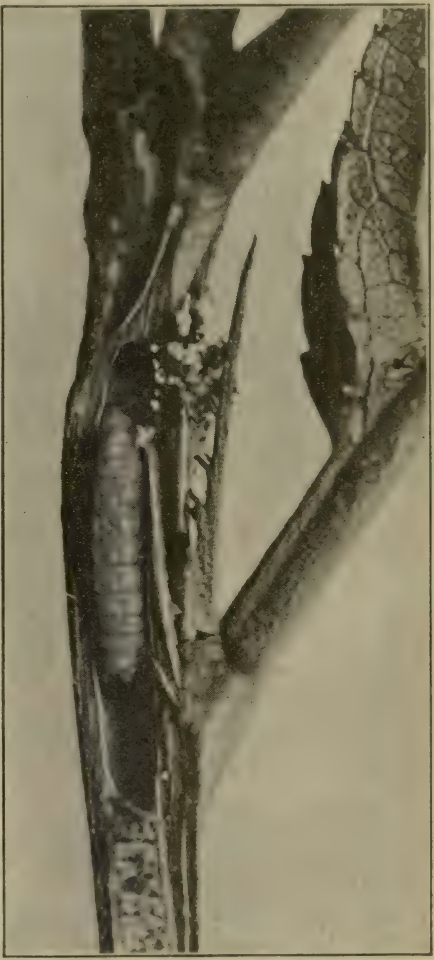

FIGURE 61.—Larva of the oriental fruit moth in a peach twig. The twig has been cut open to show the insect and its burrow. Four times natural size

ORIENTAL FRUIT MOTH

The oriental fruit moth (*Laspeyresia molesta* Busck) is closely related to the codling moth and to the lesser apple worm. It feeds in practically all fruits, but is especially partial to peaches and quinces. Apples may be severely infested late in the season, especially if close to blocks of peach trees. Early in the season the larvae feed in the young, growing shoots of peach (fig. 61), often passing from one shoot to another, and injuring several before completing larval growth. As the twigs begin to harden in the summer, the larvae attack the fruit, doing serious damage, especially to late varieties.

Unfortunately, the oriental fruit moth has been found extremely difficult to control, and practical control measures are not yet available.

PEACH SPRAYING SCHEDULE

DORMANT TREE SPRAYING

Any of the usual materials for dormant spraying may be used on peach—lime-sulphur 1–7, lubricating-oil emulsions at from 2 to 4 per cent, or miscible oils as recommended by the manufacturers. Lime-sulphur has the advantage of also being effective in the control of the peach leaf curl, a disease which is sometimes prevalent in humid sections, and which is controllable only by sprays applied when the trees are dormant. In case oil emulsion is used for dormant spraying, the addition of a Bordeaux mixture (about 3–3–50) will give good commercial control of leaf curl. When used with Bordeaux mixture for scale control the oil emulsion should be used at a slightly greater strength than when used alone. If the terrapin scale (see p. 76), or the European red mite (see p. 64), is present, oil emulsion at 4 per cent strength should be used in preference to lime-sulphur.

SUMMER SPRAYING

In the eastern half of the United States most of the peach orchards should be given the combined treatment of lead arsenate and one of the mild sulphur fungicides (self-boiled lime-sulphur, dry-mix sulphur-lime, sulphur dust, etc.) for curculio, scab, and brown rot.[16] The latter disease is more especially troublesome in the South, whereas peach scab is worst in the Allegheny Mountain area and in the Northern States.

The spray program for the South differs slightly from that recommended for northern peach orchards, because of differences in the life history of the curculio. In the South during average seasons the adults reach the orchards from hibernation early enough to be poisoned by lead arsenate applied just after the petals fall, and in many seasons there is a second brood of larvae. Farther north, on the other hand, few curculios are present in the orchard before the shucks have been shed from the peaches, and no second brood of larvae develops. Two different spray schedules are therefore recommended.

Peach spray schedule for southern orchards

(Main season varieties, such as Elberta)

First application.—When 75 per cent of the petals (pink part of flower) have fallen, use 1 pound of lead arsenate, with milk of lime from 3 pounds of unslaked lime, or with 4 pounds of hydrated lime, to each 50 gallons of water.

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[16] A detailed discussion of peach scab and brown rot, two important diseases of peach fruit, will be found in Farmers' Bulletin 1527, Peach Brown Rot and Scab, which may be obtained free upon request to the U. S. Department of Agriculture.

Second application.—When the calyces or "shucks" are shedding (fig. 62), or when the small peaches are exposed (this is usually about 10 days after the falling of the petals), use the same spray as recommended for the first application.

Third application.—Two weeks after the second application, or about four weeks after the petals have been shed, use self-boiled lime-sulphur, 8–8–50, or dry-mix sulphur-lime, for control of brown rot and scab. (No lead arsenate is used in this application.)

Fourth application.—Four weeks before each variety is due to ripen, spray with 1 pound of lead arsenate to each 50 gallons of 8–8–50 self-boiled lime-sulphur or dry-mix sulphur-lime.

Note.—Lead arsenate should not be used in all the four applications of the above schedule on account of the risk of injury to foliage and fruit.

Early peaches should be sprayed three times. Use the materials recommended for the first, second, and fourth applications, applying them at the time specified for these sprays. For added protection against brown rot in early varieties, a sulphur fungicide should be used in the second application.

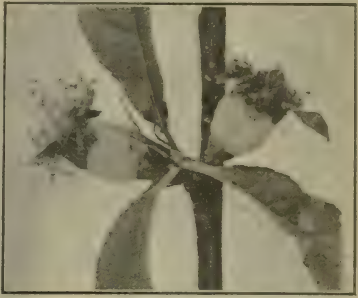

FIGURE 62.—Young peaches at the stage of growth when the "shucks" are falling; this is the proper time for the first application of spray for curculio in nothern districts, and for the second application in southern peach orchards

Peach spray schedule for northern orchards

(Main season varieties, such as Elberta)

First application.—When the calyces or shucks are shedding and the small peaches are exposed (fig. 62), use 1 pound of lead arsenate and 4 pounds of hydrated lime, or the milk of lime made by slaking 3 pounds of stone lime.

Second application.—Two weeks after the first application spray with 1 pound of lead arsenate in 50 gallons of self-boiled lime-sulphur or dry-mix sulphur-lime.

Third application.—One month before each variety is due to ripen, spray with self-boiled lime-sulphur or other mild sulphur fungicide. No lead arsenate should be included in this spray, except in case of severe infestations of curculio.

Note.—In northern peach orchards the early varieties should receive only the first two summer applications recommended for main-season peaches.

In both northern and southern peach orchards varieties maturing later than Elberta often require one or more additional applications of sulphur fungicides to protect the fruit against brown rot through the longer growing period.

DUSTING

Dust applications are made according to much the same schedule as outlined for liquid sprays, and in the northern districts consist usually of 10 per cent of lead arsenate, 80 per cent of fine dusting sulphur, and 10 per cent of a filler, as hydrated lime, which lessens the danger of arsenical injury. These latter proportions are varied more or less to meet local conditions. In southern peach orchards the lead arsenate content of the dusts is usually 5 per cent; more than this is likely to cause foliage injury.

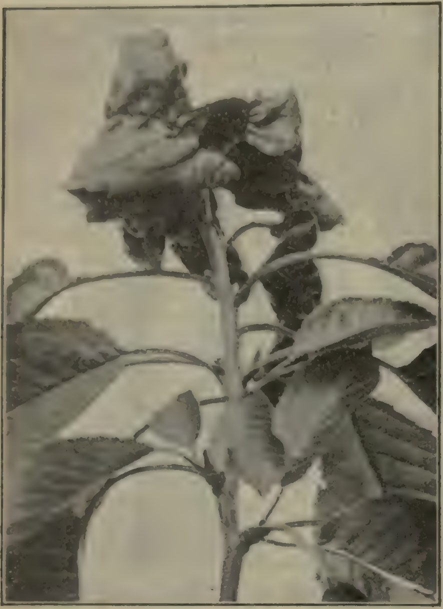

FIGURE 63.—Injury to cherry foliage by the black cherry aphid

CHERRY INSECTS

CONTROLLED BY WINTER OR DORMANT TREE SPRAYING

CHERRY SCALE

The cherry scale (*Aspidiotus forbesi* Johnson) resembles closely the San Jose scale and sometimes requires treatment. Lime-sulphur solution, oil emulsions, or miscible oils are used as for the San Jose scale.

CHERRY APHID

The cherry aphid (*Myzus cerasi* Fab.) is a black, shiny aphid which curls the tender foliage of the cherry in the spring and summer, often severely checking the growth of the trees. (Fig. 63.) It winters on the trees in the egg stage, and the young aphids upon hatching congregate on the opening buds. Thorough spraying, as the buds are breaking, with a nicotine-soap spray (p. 25) or with nicotine in winter-strength lime-sulphur spray as for apple aphids (p. 66) will be effective. Summer spraying is of comparatively little value, the insects being protected from the spray by the curled-up leaves.

CONTROLLED BY SUMMER SPRAYING OR OTHER MEASURES

PLUM CURCULIO

The plum curculio seriously injures the cherry. (Fig. 64.)

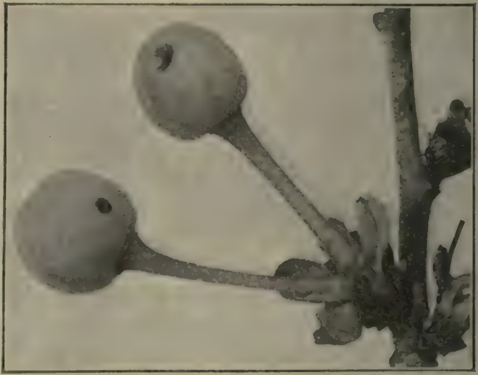

FIGURE 64.—Egg and feeding punctures of plum curculio on cherry

CHERRY FRUIT FLIES

In some parts of the Northern States cherries are sometimes infested by the maggots of two species of fruit flies (*Rhagoletis cingulata* Loew and *Rhagoletis fausta* Osten-Sacken). There is often little external evidence of infestation, though well-ripened cherries may become more or less shrunken. (Fig. 65.) Wormy cherries thus are often gathered for market or cooking purposes, the infestation being discovered first when the maggots which have deserted the fruit are found on the bottom of the container. The adult flies feed for a number of days before egg laying and can be killed if the foliage is kept covered with a poison spray. A good spray for this purpose is 1 pound of lead arsenate in 50 gallons of water. The first application should be made in early June and occasionally repeated during the succeeding three or four weeks, depending upon the extent of removal of the arsenical by rains.

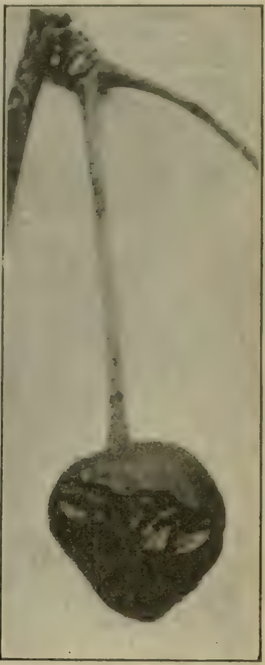

FIGURE 65.—Cherry infested with maggot of cherry fruit fly

PEAR SLUG

(See under pear, p. 74)

PEACH BORER

(See under peach, p. 77)

CHERRY SPRAYING SCHEDULE

Cherries should receive the same treatment as early varieties of peaches (fig. 66) (p. 81), except that lime-sulphur solution should be used in place of the self-boiled lime-sulphur mixture. A weaker lime-sulphur spray should be used on sweet cherries than on sour cherries, since the former are more susceptible to spray injury. Where leaf spot[17] has been severe this solution should also be used in the first treatment. For the control of leaf spot an application of the diluted lime-sulphur solution should also be made as soon as the fruit has been picked.

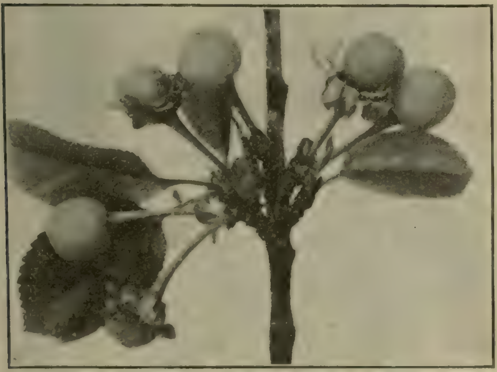

FIGURE 66.—Cherries at proper stage of growth for first spray application for curculio

PLUM INSECTS

Several peach insects, already considered, such as the San Jose scale, the terrapin and other lecanium scales, the plum curculio (fig. 67), and the peach borer, attack also the plum.

PLUM APHIDS

Three species of plant lice, the rusty plum aphid (*Hysteroneura setariae* Thomas), the hop aphid (*Phorodon humuli* Schrank), and the mealy plum aphid (*Hyalopterus arundinis* Fab.), are common on plums and often require treatment. These winter on the trees in the egg stage. The aphids hatch in the spring about the time the buds are breaking, and later may become very numerous. (Fig. 68.) In localities where injury is usual each year, trees should be sprayed as the buds are breaking, as described for apple aphids (p. 66). Otherwise it will be sufficient to spray when the aphids are actually troublesome, using nicotine sulphate (40 per cent nicotine), three-fourths of a pint to 100 gallons of soapy water, or in one of the regular self-boiled lime-sulphur mixture and lead-arsenate sprays.

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[17] For more specific information on control of cherry leaf spot, see Farmers' Bulletin 1053.

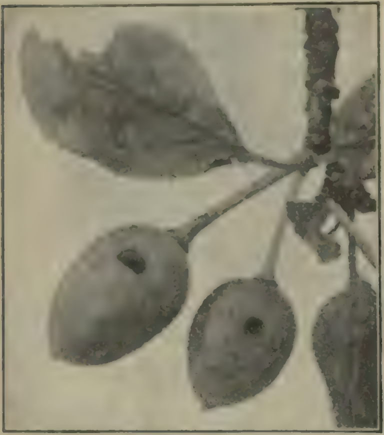
FIGURE 67.—Plums showing egg and feeding punctures of the plum curculio

PLUM-SPRAYING SCHEDULE

Japanese plums should receive the same treatment as peaches having the same ripening season. A casein-lime spreader should be added in the third application to enable the spray to stick to the smooth plum fruits.

Plums other than the Japanese varieties should receive the treatment outlined in the peach-spraying schedule, except that lime-sulphur solution diluted in the proportion of 1 gallon to 50 gallons of water is to be preferred to the self-boiled lime-sulphur mixture or dry-mix sulphur-lime as a fungicide.

GRAPE INSECTS[18]

CONTROLLED BY SUMMER SPRAYING

GRAPE BERRY MOTH

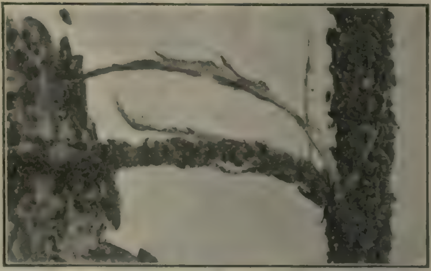
FIGURE 68.—Colony of the rusty plum aphid on plum

In late summer grape berries are often found infested by an active, greenish caterpillar about three-eighths of an inch long, the larva of the grape berry moth (*Polychrosis viteana* Clem.). It is at present destructive in northern Ohio and to a less extent in portions of the Chautauqua and Erie grape belts, as well as in other northern grape-growing districts. First-brood larvae feed on the blossom or young fruit clusters, and those of the second brood injure the green and ripening berries, often causing so much damage that the grapes must be carefully picked over by hand before being marketed. (Fig. 69.) The insect is usually well controlled by a lead arsenate spray of 1½ pounds to 50 gallons of Bordeaux mixture, applied just after the blossoms have fallen and again two weeks later. (See Spraying Schedule, p. 89.)

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[18] The insects attacking the grape are discussed in greater detail in Farmers' Bulletin 1220, Insect and Fungous Enemies of the Grape, which may be obtained free upon request to the U. S. Department of Agriculture.

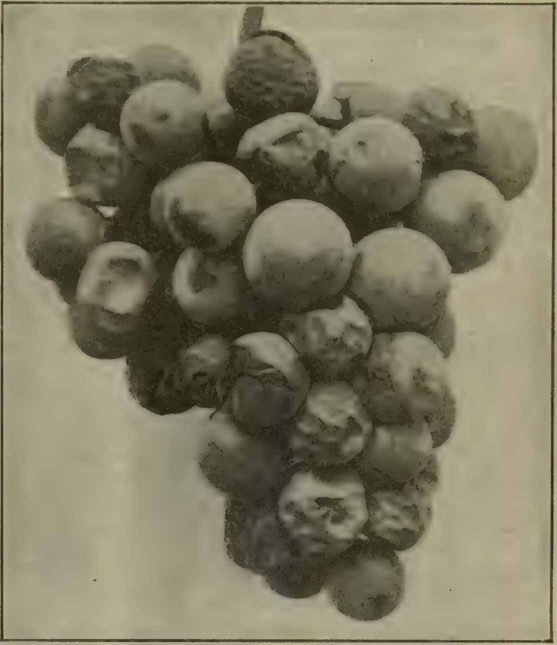

FIGURE 69.—Grapes injured by grape berry moth larvae

GRAPE ROOTWORM

The presence of the grape rootworm (*Fidia viticida* Walsh) in vineyards is shown by chainlike feeding marks of the adult beetles on the foilage. (Fig. 70.) The larvae consume the fibrous roots of the grape and eat out furrows in the larger roots, stunting the growth of the vine; and as a result the foliage becomes yellowish, and the fruit may shrivel and fall. It is a serious pest in the Erie-Chatauqua and northern Ohio grape districts and requires annual treatments to keep it reduced below injurious numbers. Since the beetles feed on the leaves during early summer and before egg laying to any extent, they may be controlled by the use of arsenical sprays applied in Bordeaux mixture, as described for the berry moth in the spraying schedule (p. 89).

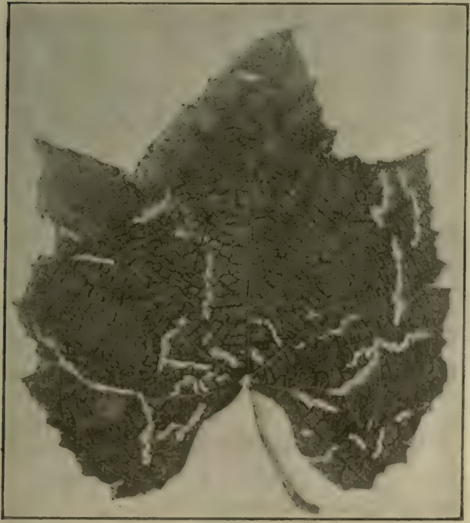

FIGURE 70.—Characteristic chainlike feeding marks of adults of the grape root worm

GRAPE LEAF HOPPER

The grape leaf hopper (*Erythroneura comes* Say, and related species) is a small, agile, whitish insect with red and yellow markings often noted as abundant during summer on the lower surface of grape leaves. It feeds by sucking juices from the leaves, and its punctures cause the foliage to become blotched with white (fig. 71) and later to turn brown, many of the leaves falling from the vines. This injury interferes with the proper ripening of the fruit and prevents normal vine growth. The insect is a pest of much importance on American varieties of grapes throughout the country generally, and especially in the Great Lakes area, and also on vinifera varieties in some sections of the West. It is controlled by the use of one-fourth pint of nicotine sulphate (40 per cent nicotine) to 50 gallons of soapy water, or Bordeaux mixture. The first application should be made when the wingless hoppers or nymphs of the first brood are present in large numbers (in the North this will be in late June or early July), as can be determined by examination. The nicotine should be used in the lead arsenate and Bordeaux mixture spray described in the spraying schedule (p. 89). Much care is necessary in spraying to hit the insects on the lower surface of the leaves.

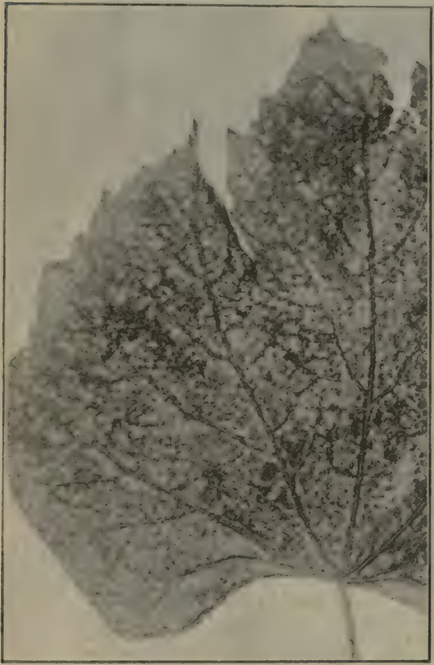

FIGURE 71.—Mottled appearance of grape leaf following attack by the grape leaf hopper

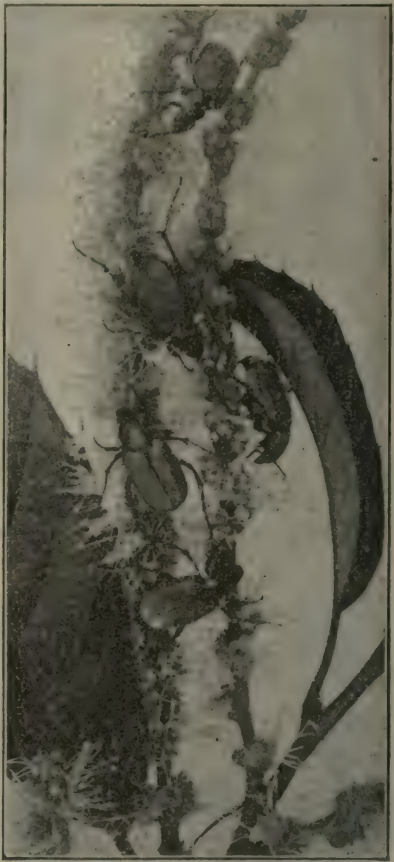

FIGURE 72.—Rose chafer, or "rose bug": Beetles attacking chestnut blossoms. Slightly enlarged

ROSE CHAFER

In some sections of the country the long-legged, yellowish-brown beetles, about one-half inch long, known as rose chafers (*Macrodactylus subspinosus* Fab.) (fig. 72) often put in appearance in large numbers about the time of blossoming of the grape, as well as of roses and many other garden flowers, stripping the plants of blossoms and foliage. They feed upon a large variety of plants, and when very abundant do much damage in spite of treatment. Thorough spraying upon first appearance of the beetles is recommended, using 2½ pounds of lead arsenate for each 50 gallons of water, repeating the application as necessary to keep the plants coated with poison. Hand picking of beetles in the early morning may be practiced on a small scale, and bagging choice plants with mosquito netting may also be resorted to.

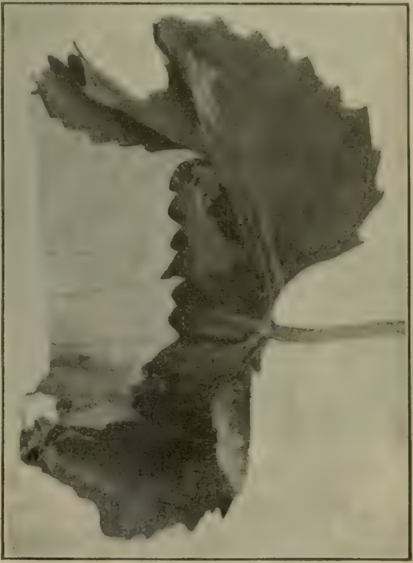

FIGURE 73.—Work of grape leaf folder on grape leaf

GRAPE LEAF FOLDER

Grape leaves are often rolled or folded over (fig. 73) by an active, grass-green caterpillar about three-fourths of an inch long, the so-called grape leaf folder (*Desmia fureralis* Hübn.). Within the folded leaf the larvae eat out the soft leaf substance, and when numerous may cause more or less defoliation of the vines. The larvae of the first brood appear on the vines in early summer. Well-sprayed vineyards are not seriously troubled by the leaf folder, and its injuries are usually confined to the home vineyard. Spraying the vines with lead arsenate, 1 pound in 50 gallons, when the larvae are first in evidence will keep them in check. Hand picking of infested leaves or crushing the larvae in the folded leaves is practicable where only a few vines are involved.

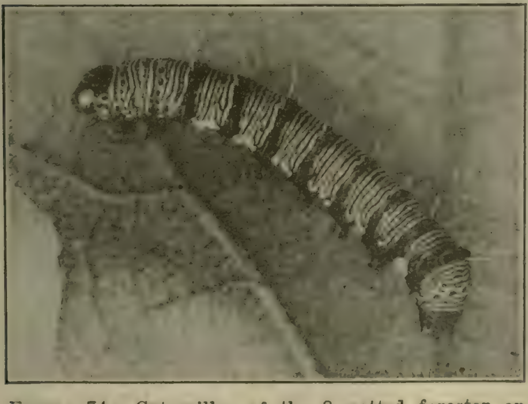

FIGURE 74.—Caterpillar of the 8-spotted forester on grape leaf. About twice natural size

EIGHT-SPOTTED FORESTER

The caterpillar of the moth known as the 8-spotted forester (*Alypia octomaculata* Fab.) feeds on grape foliage and is sometimes much complained of locally. The full-grown caterpillar (fig. 74) is about 1⅓ inches long with transverse black and orange stripes or bands, and there is a distinct hump near the hind end. Larvae are present on the vines from early June until about August. They may be controlled by the use of lead arsenate, as described for the grape leaf folder.

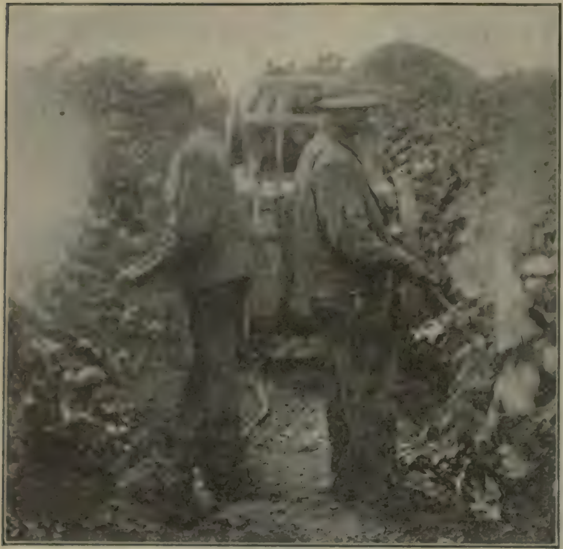

FIGURE 75.—Spraying grapes by the "trailer method," the short spray rod being held in the hand

GRAPE FLEA BEETLE

A small steely blue beetle, known as the grape flea beetle (*Haltica chalybea* Illiger), often attacks the swelling buds of the grape in the spring. The larvae of the beetles later feed upon the foliage. Where injury by this pest has been prevalent or is to be expected, vines should be sprayed as the buds are swelling with 1½ pounds of lead arsenate to 50 gallons of water or fungicide. The larvae of this insect usually are kept in check by the lead arsenate used in the first and second applications of the spray schedule (p. 89).

GRAPE SPRAYING OUTFITS

Two types of equipment are used with power outfits for spraying vineyards. The use of one type of equipment is known as the "trailer method" (fig. 75) and involves the application of the materials by means of short rods in the hands of operators who walk behind the spray outfit. A second type of equipment is known as the "boom" or "set nozzle" sprayer (fig. 76). In this case the vines are sprayed from both sides from a number of nozzles so placed that the spray converges from several directions at the same time.

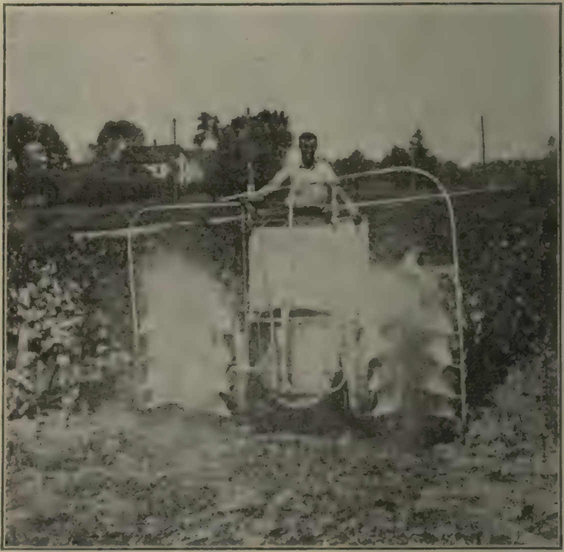

FIGURE 76.—Boom attachment for vineyard sprayer. Two rows of grapes are treated at a time with spray converging from two sides

GRAPE SPRAYING SCHEDULE

First application.[19]—About a week before the blossoms are expected to open, or when the shoots have become from 12 to 18 inches long,[19] spray with Bordeaux mixture 4-3-50 (p. 27) for fungous diseases, adding from 1 to 1½ pounds of lead arsenate for the flea beetle, the rose chafer, etc.

Second application.—Just after the blossoms have fallen spray with the same materials as in the first application for the same fungous diseases and insects and for the grape berry moth, grape leaf folder, and adults of the grape root worm.

Third application.—About two weeks later use Bordeaux mixture 4–3–50 with 1 to 1½ pounds of lead arsenate, ¼ pint of nicotine sulphate (40 per cent nicotine), and 1 pound of rosin-fish-oil soap to 50 gallons of spray mixture, for fungous diseases, berry moth, eight-spotted forester, grape leaf folder, grapevine aphid (*Macrosiphum illinoiensis* Shimer), grape root worm, and grape leaf hopper. To destroy the leaf hopper direct the spray against the lower surface of the leaves. To control the berry moth, thoroughly coat the grape bunches with the spray.

Fourth application.—About 10 days later, or when the fruit is nearly grown, if black rot or mildew are still appearing, spray with neutral copper sulphate or verdigris [20] in the proportion of 1 pound to 50 gallons of water.

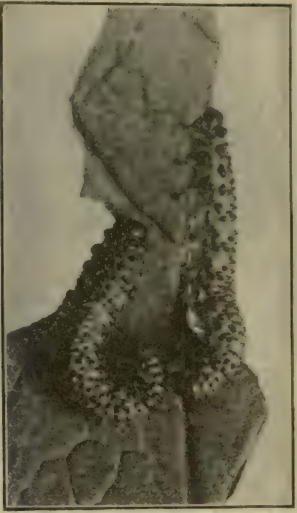

FIGURE 77.—Imported currant worm and its injury to currant leaf. About four times natural size

CURRANT AND GOOSEBERRY INSECTS

CONTROLLED BY WINTER OR DORMANT SPRAYING

The San Jose and certain related scales are frequently present in injurious numbers on currant and gooseberry plants, the first mentioned being especially likely to require treatment. The dormant sprays recommended for the control of this insect on fruit trees (pp. 11 and 17) are equally effective in controlling it on currant bushes.

CONTROLLED BY SUMMER SPRAYING

IMPORTED CURRANT WORM

The imported currant worm (*Pteronidea ribesii* Scop.) when full grown is about three-fourths of an inch long, uniformly green with the exception of the ends, which are yellowish. Young larvae are covered with black spots, and the head is black. (Fig. 77.) They attack both currants and gooseberries, appearing on the plants shortly after the leaves are out in the spring, feeding at first in colonies but later scattering over the plants. Currant worms are voracious feeders and quickly strip the plants of foliage, hence treatment should be given promptly upon their discovery. Another brood of larvae appears in early summer, and in some seasons there may be a partial third brood. These insects are destroyed readily with an arsenical, sprayed or dusted over the plants. Effort should be made to destroy the first brood and prevent later injury. When the fruit is ripening, powdered hellebore should be substituted for the arsenical and should be diluted from five to ten times with flour or air-slaked lime; or used as a spray, 1 ounce to 1 gallon of water.

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[19] In sections where grape black rot is serious, it is essential to make an earlier application of Bordeaux mixture when the young shoots are but 2 or 3 inches long.

[20] Verdigris is basic acetate of copper.

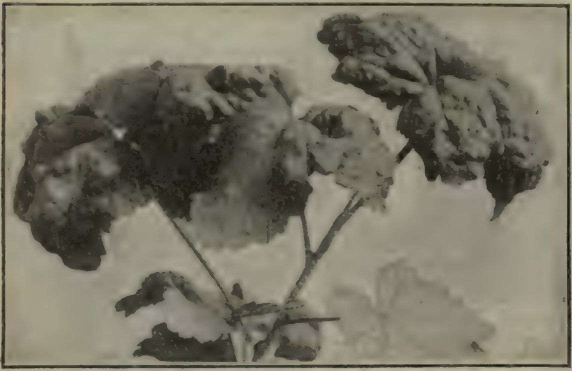

FIGURE 78.—Currant leaves curled by the currant aphid

CURRANT APHID

The currant aphid (*Myzus ribis* L.) curls the terminal leaves of the currant and gooseberry, especially the red currant, its presence resulting in little pits or pockets on the lower leaf surface. (Fig. 78.) A reddish color usually develops on the upper surface of injured leaves, which is visible some distance away. The aphid is easily controlled by spraying the plants as the leaf buds are opening in the spring, thus destroying the young stem mothers. The nicotine sulphate soap spray, or kerosene emulsion or fish-oil soap wash, should be used. In spraying later in the season the liquid should be directed against the insects on the lower surface of the leaves.

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JUN 17 '33

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1667

RURAL COMMUNITY FIRE DEPARTMENTS

1862 1889

THIS BULLETIN presents the summarized results of a field survey of rural fire departments that serve farmers, especially those that concern farmers through ownership or financial interest. Local investigations were made to ascertain the effectiveness of these departments in the reduction of the great fire losses in farming communities and the accompanying social distress.

Eighty rural fire departments were covered. Case studies were made of 52, and information was secured locally concerning 18 others. Indirect but apparently reliable information was received concerning the successful operation of more than a hundred others.

One from each of the several types of fire organizations giving service to farms is described in this bulletin in the hope that any interested community will find at least one type that would suit its conditions.

Although in many places rural fire departments are practically unknown, in other sections they are successfully operating in large numbers. This would seem to indicate that where the successful operation of one such department became known others were soon organized in neighboring communities.

Washington, D. C. **Issued July, 1931**

RURAL COMMUNITY FIRE DEPARTMENTS

By WAYNE C. NASON, *Assistant Agricultural Economist, Division of Farm Population and Rural Life, Bureau of Agricultural Economics*[1]

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INTRODUCTION

FARMERS AND RURAL PEOPLE of the United States are just discovering the value of fire departments in farming communities. Formerly the attitude toward a farm fire was generally one of fatalism; it was considered one of those things which just happened and about which little could be done. The unfortunate farmer, perhaps already hard pressed for money, lost his house, his barn, or all his buildings, his household effects, perhaps his machinery, grain, and hay, perhaps all his food supplies. A member of his family may have been killed in such a fire—it is estimated that every year 3,500 people on farms lose their lives by fire. The farmer's capital and investment and the accumulations of many years of hard work may have been wiped out in a day. But what could be done about it?

The town fire victim may lose his home or his place of business, but seldom both; the farm fire victim may lose not only his house but the farm buildings, which are the factory of the farm where various farm processes are carried on. After a town-home fire the next-door neighbor often takes in the victims; in farm-home fires the family may find a home far from the farm.

Record books kept by fire departments, in which statistics and information concerning each fire were entered, and the minutes of the meetings of farm fire associations were used in obtaining information about organization and operation and concerning the types of apparatus used, the number and kinds of fires, and the effects of particular farm fires.

In evaluating the effectiveness of rural fire departments, interviews were had with rural fire fighters, rural government officials, members of rural fire associations, and representatives of agricultural interests, and with those who had called upon rural fire departments for help. Inspections were made of the results of many farm building and grain fires that were fought by such fire departments and more than a hundred interviews were held with those who suffered from such fires.

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[1] The Chemical Engineering Division of the Bureau of Chemistry and Soils and the farm fire-protection committee of the National Fire Protection Association, whose chairman is connected with the Bureau of Chemistry and Soils, gave counsel in the preparation of this study. Helpful suggestions were contributed by the member of that committee who represents the Division of Agricultural Finance of the Bureau of Agricultural Economics.

In the 52 case studies, an attempt was made to set forth clearly such factors as organization, method of finance, contractural relationships, social effects and implications, actual operations and results.

Rural changes and improvements of the last dozen years have brought about a change in the attitude of people on farms toward farm fires. Motorized fire apparatus, good roads, rural telephones, farm business associations, and town and country cooperation have made farm and rural fire departments practicable and advisable.[2] Distance up to 8 or 10 miles, if roads are good, has ceased to be the most important factor in fighting farm fires. Modern motorized apparatus now leaves a central point, generally in a town, and arrives at a farm fire several miles distant nearly as quickly as city fire equipment leaves its station and arrives, through congested traffic, at an outlying residence fire. The farm telephone starts the fire apparatus on its way almost as quickly as does the city fire alarm.

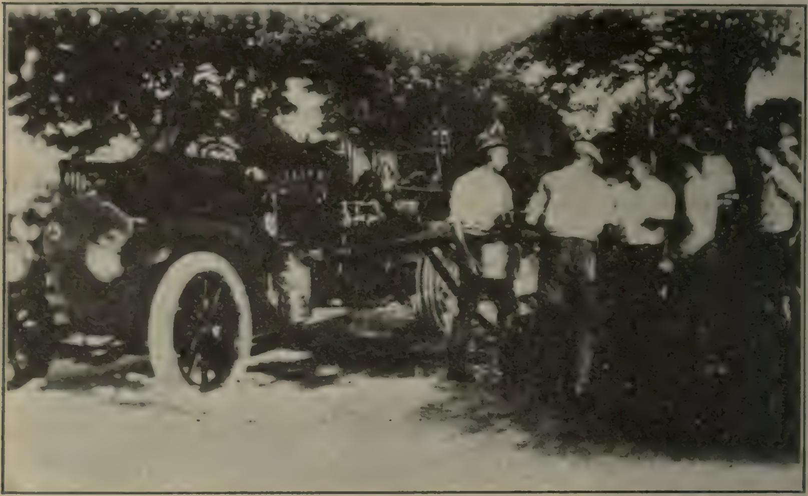

FIGURE 1.—A bucket brigade bringing water to a barrel, from which the suction hose of the Wicomico County, Md., rural fire truck took water to the booster tank of the truck, from which it was forced onto a barn fire at Quantico, Md. The truck had a 9-mile run. The barn burned, but adjacent buildings were saved

Rural equipment adapted to motorized fire apparatus is overcoming bad road conditions and limited water supply where such conditions exist. Whether water is plentiful or scarce, the chemical apparatus is useful. Where water is scarce members of farm fire associations are making it available by the construction of outdoor cisterns, pools, wells, and windmills, the damming of creeks, the transportation of water from near-by farms in milk cans, etc. (Fig. 1.) Rural firemen are displaying remarkable ingenuity in overcoming water deficiency by connecting with windmill tanks, by multiple hose connections, and by arranging relays of fire trucks, etc. Those who give water insufficiency as an insuperable obstacle to the general establishment of rural fire departments are finding their arguments refuted.

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[2] "Rural fire departments are now in use in many parts of the country and are very successful." From the pamphlet The Rural Fire Department, by the National Fire Waste Council. [Now out of print.]

Special enabling acts for the establishment of rural fire departments have recently been enacted in a number of States.[3] In other States the departments are being established according to existing statutes. Special legislation facilitating the action of departments already organized and legislation removing obstacles to their successful operation are other recent developments. As a result, several hundred successful rural fire departments in which farmers have a financial interest, practically all organized within the last dozen years, are now in existence.

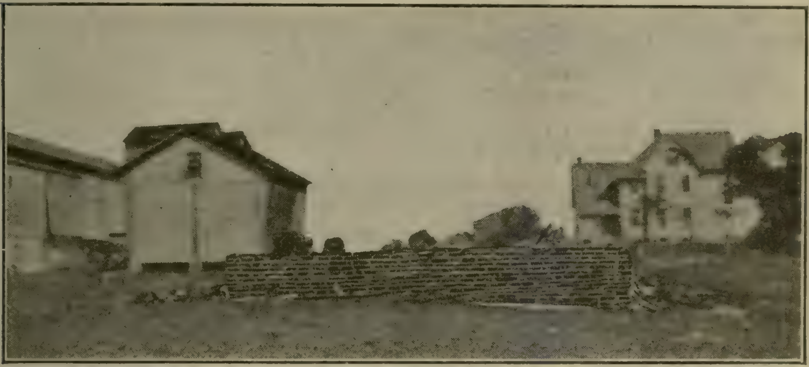

FIGURE 2.—Granary foundation wall left after a fire on the farm of J. C. Lincoln, 5 miles from Medina, Ohio. The fire, fought with the Medina community fire apparatus, was caused by the explosion of a tractor. The close group of seven farm buildings and contents was insured for $18,000; all would have burned, according to the fire chief, if the fire apparatus had not come. Only the granary burned. The filled corncrib (center) was on fire on both sides when the apparatus arrived. Water to control the fire was secured from a well beside the house

In 1925 there were 6,371,640 farms in the United States. The insurable farm property, on the basis of the 1925 census figures, is estimated at $23,100,000,000. The committee on farm fire protection of the National Fire Protection Association estimates the loss from fires on farms as approximately $100,000,000 annually. Nearly one-fourth of the national fire loss occurs on farms. These figures do not represent all the loss. Food supplies and productive goods are lost, as are raw materials upon which city industries depend. The farm factory suspends business for a time. Taxable property is lost. Farm families are made homeless. Through social and economic loss it becomes a national problem. The relatively high cost of building material and farm machinery and the introduction of electric machinery and equipment on the farm makes the problem more acute. (Fig. 2.)

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[3] See Farmers' Bulletin 1643, Fire Safeguards for the Farm, pp. 21–22.

Insurance, valuable though it be, is apparently not completely meeting the issue for the farmer. In the final result farmers pay all farm insurance losses, as the insurance company is only the collector and distributor of funds. Many insurance companies object to having a town fire apparatus leave the town, especially if the town is left unprotected, and threaten to raise insurance rates in the town if this is done. The town business man deplores any increase in his insurance rate but often seems to think that the adjacent farmers' fire loss of several thousand dollars is more or less inevitable. Towns find it difficult to refuse apparatus when a farmer calls; many do respond to country calls, even leaving the town unprotected, but town apparatus is not always suited for farm fire fighting or for traveling on country roads. The personnel are not accustomed to country conditions and are seldom trained in farm fire-fighting methods.

Farmers do not pay taxes for town fire apparatus and can hardly expect to depend upon it. Two pieces of apparatus, one for town and one for country, may solve this problem. Fire departments in which farmers are interested through finance, ownership, control, or agreement, which study and understand farm fire-fighting conditions, and which have suitable apparatus for country situations give the most promise toward the solution of the farm-fire problem, according to investigations made.

Insurance companies, in determining town rates, give credit for well-equipped fire departments. They are reluctant to do this, however, in the case of farm fire departments, perhaps because of natural conservatism and perhaps because of a lack of understanding of the effectiveness of such departments. Insurance companies are guardians of the money they handle and must be shown the effectiveness of rural fire departments before credit is given. This development is necessarily slow.

The Fire Underwriters of the Pacific, San Francisco, Calif., have taken an advanced step in this matter. Urged by agricultural extension workers and with the governor of the State manifesting interest, this rating organization is giving credit up to 25 cents per hundred dollars, effective 1929, in the case of insurance on growing grain, to insured farmers in rural fire-protection districts organized according to State law. Recognition was given even to new and untried organizations and equipment that had been graded, and to farmers' fire departments organized under no special fire department law. Of 26 rural fire districts applying for recognition in 1929, 24 were recognized; the other 2 failed to submit the required district maps.

A representative of the underwriters has this to say:

> Reports have come to our office of very effective work done by these districts. A superficial investigation shows that, for 1929, there has not been a serious grain loss in any of our rated districts. The possibilities for rural protection are almost infinite and within a comparatively short time I feel that all rural property will be under fire protection. The rating of rural distiets is here to stay. While grain fires are the chief problem of California farmers, we are now working on a system of giving credit for rural building fires.

Rural fire departments have ceased to be an experiment and are now advocated by farm organizations, by agricultural extension workers, insurance journals, farm papers, fire prevention periodicals, underwriters' associations, the National Fire Waste Council, the National Fire Protection Association, State industrial and insurance commissions, insurance companies, and others who have made an actual study of their effectiveness in meeting the growing farm fire menace.

HOW RURAL FIRE DEPARTMENTS ARE FINANCED

Rural fire departments are financed in various ways.

The principal methods found were (1) governmental, involving direct appropriation, tax levy, or bond issue, through counties, townships, rural fire districts, or towns, or one or more of these combined; (2) public subscription by farmers or townspeople, or both, or the formation of an association and the selling of the stock or charging a membership fee; (3) receipts from entertainments generally given by fire departments; and, (4) farmers' insurance companies, through assessment of policyholders.

Governmental agencies took part in financing 54 of the 80 departments studied. Counties took part in 15, townships in 7, rural fire districts in 18. Los Angeles County, Calif., voted the formation of 28 legal fire districts in unincorporated territory in an area of 184 square miles. These were organized locally, and provided themselves with valuable apparatus, fire departments, and fire houses. The Fremont, Calif., rural fire district, around but not including the village of Mountain View, financed its first-year budget of $11,000 for 1929, to cover apparatus and maintenance, by a tax of 47 cents on the $100. The second year, with an 11-cent tax, found the district out of debt and with a surplus. Further annual tax decreases are expected.

Wicomico County, Md., in 1925, appropriated $6,000 for one county-and-town engine costing $10,000, to which the town of Salisbury added $4,000, and $4,000 to help promote four rural community fire departments. By special act of the Maryland Legislature the county now annually appropriates $6,000 for assistance, divided equally among eight rural communities, only two of which had apparatus prior to 1925. Four townships appropriated for the apparatus at Chardon, Ohio. As a result of petitions, Hamilton Township, N. J., permitted the formation of nine fire districts.

The 54 governmental appropriations included supplemental appropriations by 20 towns; the apparatus was made available for the towns and, in some instances, was primarily for towns. One township contracts for service from the town of Freehold, N. J. Several villages contract for service from the town of Great Neck, N. Y. Easton, Md., appropriated $500 toward the country apparatus so that the town apparatus need not leave the town. For the same reason many towns took similar action.

Farmers contributed toward 28 pieces of apparatus, and gave practically all the money for 12 pieces; the average cost of these pieces of apparatus was about $4,000 each. Townspeople cooperated with farmers in subscribing for 15 pieces and bought 3 pieces without the farmers' aid. In some cases farmer contributions were uniform, about $25 apiece, and in others they were free-will contributions of varying amounts. The initial contribution usually allowed them free fire service during the life of the truck. The farmers near East Berlin, N. Y., subscribed on the basis of $4.40 per $1,000 of assessed valuation of their land. The village of Bascom, Ohio (population 401), and the farms around it were divided into three zones, and the inhabitants voluntarily assessed themselves according to the value of their taxable buildings and contents—those in the inner zone 1 per cent, those in the middle zone 0.75 per cent, and those in the outer zone 0.5 per cent. In the 14 square miles of territory, the sets of buildings or "memberships" that entered voluntarily, were 790; only 11 did not enter. The amount of $12,500 was obtained for a fire house and apparatus.

One farmer near Plainfield, Calif., who owns 1,500 acres, has his own fire truck, and neighboring farmers make arrangements for the use of it.

Fire-department entertainments contributed funds to 10 departments. This was an effective method in the East, especially in Maryland, Virginia, and Pennsylvania. The 1928 carnival week of the fire department of Sharpstown, Md., cleared $3,200 for the rural apparatus. Carnivals produced $2,500 for the apparatus at Ashland, Va. Carnivals and moving pictures were most effective in financing and maintaining the department at Bernville, Pa. (See p. 27.)

Farmers' mutual insurance companies frequently contribute to the purchase and maintenance of rural apparatus. The Fall Creek Farmers' Mutual Fire Insurance Co. of Wisconsin, through membership assessment, bought apparatus for $4,500 and contracted with the local fire department for the latter to serve town and country people. The Farmers Mutual Fire Insurance Co., East Troy, Wis., and the village purchased apparatus jointly.

Townspeople cooperate with farm people in the purchase of apparatus because (1) it often furnishes a second piece of apparatus so that the town is not left unprotected, (2) town interests realize their dependence upon agriculture, and (3) it promotes town and country cooperation.

Taxation is generally considered the most equitable way of financing, since it puts all on a footing of equality in financing and right of service.

TYPES OF RURAL FIRE DEPARTMENTS, WITH EXAMPLES

Brief descriptions are given of a number of rural fire departments, including their origin, cost, kind of apparatus, method of finance, maintenance, ownership, control, kind of organization, operation, and their experiences in fighting farm fires.

On the basis of such factors as origin, ownership, control, finance, organization, and use, five types are found: Farm, fire district, community, township, and county. In most instances the group purchases the apparatus and contracts with a fire company to serve that group. In some instances the group purchases the apparatus and organizes a fire company.

FARM FIRE DEPARTMENTS

In most instances farmers organize a farm fire association, buy apparatus, and contract with an organized town fire company through the town, or with a volunteer company direct, to serve members of the farm association. Farmers who are not members of the association may be served for a fee for each fire. Farmers' associations generally contract with an organized fire company because fire fighting is a definite business necessitating trained men in a well-organized company, not only to fight fires but to care for specialized apparatus so that it will always be in condition to use.

Some town fire companies in which farmers have no financial interest will fight farm fires in a casual way, but such action is only secondary to the main occupation of fighting fires in town. Farmers have found it to their advantage to finance and own their apparatus, contracting with the town or the town company to house and maintain it and to serve the farmers with it. In return, the town may use the farm apparatus for a town fire if it is not needed at the time for a farm fire. Some farm fire associations organize and control their own companies.

FARMERS COOPERATE WITH A VOLUNTEER FIRE COMPANY, WATERTOWN, MINN.

The Progressive Farmers Club, in 1925, wanted to buy fire apparatus to serve the farmers around this village of 534 people. The village had had a volunteer company for some time but no motorized apparatus.

The farmers' club started propaganda for the purchase of modern motorized apparatus by farmers to be turned over to the village to be used by the village fire company in combating farm and village fires. Committees of farmers were appointed to solicit subscriptions in a territory extending five miles out on each road from the village. Single farms were apportioned $15; in the case of a rented farm the owner paid half and the renter half. The village commercial club, which included farmers, backed the campaign.

After two weeks' intensive campaign, $4,118 had been subscribed by 312 farmers, subscriptions ranging from $7.50 to $25 each. In addition, the farmers' creamery company gave $500; village industries interested in agriculture contributed $1,200 (the canneries $100, lumber company $100, shipping association $500, and telephone company $500). From the sale of old equipment turned over by the village $600 was realized. Thus $6,418 was raised for the new apparatus.

A combination chemical and pumping engine was bought. It has a 6-cylinder, 70-horsepower motor with dual-ignition system. Tires are 36 by 6 inches, and the wheel base is 154 inches. The pump has 30 feet of 4-inch suction hose, two 40-gallon soda and acid chemical tanks with 150 feet of special chemical hose, and two 2½-gallon hand chemical extinguishers. It has a maximum capacity of 450 gallons per minute at a pressure of 120 pounds. Additional equipment consists of ladders, a swinging searchlight, axes, crowbars, poles, etc. Later the town turned over 1,000 feet of hose and two 2½-gallon hand extinguishers for oil fires. (Fig. 3.)

The original apparatus and equipment cost $5,300. A siren was bought for $403.75 and connected with the telephone central office, and a switch was put in the town hall. Other expenses were: Travel to apparatus factory, $10; printing, $10.75; engine testing by State, $4.25; labor and material for erecting siren and wiring, $281.67. Total disbursements from the $6,418 collected were $6,010.42; balance, $407.58. Later the farmers bought other equipment for $500.

When the apparatus was delivered a public demonstration of its effectiveness was given before a large crowd of farmers and townspeople. On August 31, 1925, the apparatus was officially turned over to the town at a banquet given in the creamery auditorium by the commercial club to 500 people, including the farmer donors.

The written agreement between the farmers and the village is as follows:

> This agreement made and entered into this first day of September, 1925, by and between the duly constituted authorities of the village of Watertown, hereafter called "the party of the first part," and several subscribers to this document, hereafter called "the parties of the second part," witnesseth that for and in consideration of the several sums subscribed herein by the parties of the second part for which they will buy a suitable piece of motor-driven fire apparatus, the party of the first part herein agrees to accept said motor-driven apparatus and keep it in first-class repair and running order at all times, to provide a suitable housing for said equipment, and also provide men to handle same. Party of first part hereby agrees that in case of fire on any property belonging to parties of second part that, being properly notified, the authorities of the village of Watertown will cause the above-mentioned apparatus to go to the relief of the parties of the second part and render all possible assistance toward the extinguishment of the fire and the salvage of the property involved, provided, however, that a fire is not raging at the time in the village of Watertown, and provided also that the apparatus is not responding to an alarm in some other district. Party of the first part agrees to use every possible means to the relief and assistance of parties of the second part but parties of the second part hereby agree not to bring suit for damages against parties of the first part should the truck fail to reach the scene of the fire due to bad roads or other unforeseen conditions over which party of the first part has no control. It is expressly agreed and understood that said apparatus is to be used by the fire-fighting organization of the village of Watertown for the extinguishment of fires in the limits of the village of Watertown and for the several other subscribers called party of the second part.

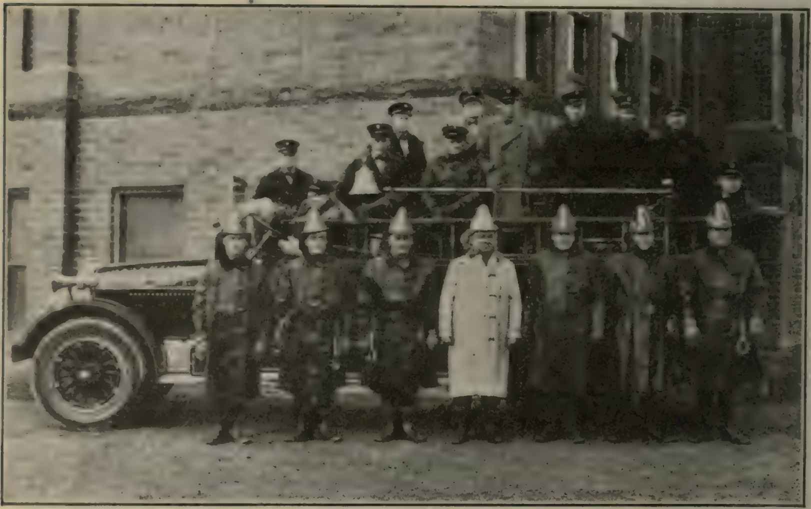

FIGURE 3.—Rural community fire apparatus purchased through the Progressive Farmers Club, Watertown, Minn., and manned by the village fire department

The agreement is supposed to last during the life of the truck. Thus the town must house, maintain, and man the apparatus and fight farm-member fires, in return for which it may use the truck to fight town fires.

Six farmers have subscribed since the purchase of the truck and others may later. Subscribers get service of the truck free; non-subscribing farmers pay $45 per hour of service. The village pays its fire company $1 an hour for each fireman for the first two hours and $0.50 for each additional hour for answering village calls. This goes into the firemen's equipment fund.

After the truck was bought the volunteer fire company reorganized and solicited new members. Forty-three men applied; 20 became active members and the others reserves, making an available force of 60 men.

The balance on hand in the fire department January 1, 1928, was $286.81. Receipts for the year 1928 were $412.40, and disbursements were $466.70. The balance on hand January 1, 1929, was $232.51.

During 1928 the department responded to 18 calls—10 from farm subscribers, 6 in the village, and 2 from neighboring villages.

In serving the farmers the apparatus has little trouble with roads, as they are well gravelled. At first there was some trouble getting sufficient water. In four instances several farmers who live near together have built neighborhood cisterns, and two farmers have built individual cisterns near the centers of their building groups.

The value of morale in a volunteer fire company is recognized. At the annual picnic with neighboring firemen competitive games are played; there is an annual dance and occasionally others; social events often follow the regular monthly meetings; and fire-fighting demonstrations are given at neighboring towns. The company is a member of the State and district volunteer firemen's associations and of the State volunteer firemen's benefit association. Delegates are always sent to the State firemen's convention.

Fire officials and farmers expressed satisfaction in the apparatus and the results in suppressing farm fires. The fire chief said:

> The arrangement works well and little trouble is encountered in combating farm fires. It is a splendid thing for the farmers. More than the price of the truck was saved at the first few farm fires.

Concerning the Murphy fire, 6 miles from town, at which the chief stated they were handicapped by a lack of water, Ed Murphy said:

> Our house fire occurred at midnight when we were all in bed. The department was not called until the house was about one-half burned. The house couldn't be saved but the department and the wind saved all the other buildings. The department did good work. All farmers like it.

FARMERS COOPERATE WITH A PAID FIRE DEPARTMENT, BELVIDERE, ILL.

"I should say not. To charge $25 for one set of buildings is too much. Never had a fire and probably never will." This was the reported response of one farmer near Belvidere to the request that he subscribe $25 toward the purchase of a farmers' fire truck and receive free service. But the fire truck was bought by the farmers, and an agreement was made with the town that the town fire department would respond to farm calls. The first call came from the farmer who never had had a fire. After several buildings were on fire and bucket-brigade fire fighting had failed, he decided to call the department, 6 miles away. The farmers' truck responded, and shortly the fire was put out. As the farmer didn't expect a fire he was not supplied with sufficient water. A dam was hurriedly made by the fire department in a ditch nearly 200 yards away. Although a large barn burned, the intermittent supply of water through the nozzle strainer saved three buildings that were on fire and other property, the value of which was more than the price of the truck.

The second call was also from a nonsubscribing farmer who lost a machine shed, but buildings 15 feet away were saved. Concerning this fire the Rockford Morning Star, April 11, 1929, said: "The farm fire truck purchased by Boone County farmers demonstrated its value a second time last night."

A third call was from a nonsubscribing farmer 6 miles out. Three complete sets of farm buildings were in a close group housing three families. Because of a lack of sufficient water, the stock tanks being empty, an autotruck was used to carry water in milk cans to the fire-truck tank. Although there was a high wind, only a barn was burned.

Concerning this fire, one of the farm occupants said:

> There was no way to stop the fire in the barn which was in flames before the truck arrived 10 minutes after I called. The other buildings might have burned if the truck hadn't come. The rural fire department is a very good thing.

The fourth call, also from a nonsubscriber, was at 3 o'clock on a rainy night. Lightning had struck the hog house in a valuable group of farm buildings. Only the hog house burned.

The county agent and the farm bureau were largely instrumental in procuring this truck. The town department had been answering farm calls incidentally. On one of these occasions the apparatus became stuck in the mud, and townspeople protested its use in the country. Country water was dirty and injured the piston pumps of the apparatus which had intakes and outlets that were too large; it had a 750-gallon pump capacity, which is too high for effective country use. The city attorney questioned the legality of using the town apparatus outside the town.

Not wishing to refuse farm calls, the town council ruled that the town apparatus would respond to country calls at $50 for the first hour and $25 for each succeeding hour, payment guaranteed by a responsible party.

A meeting of farmers was called, the question was discussed, and the purchase of a farmers' truck was voted. It was decided to raise $4,500, including $700 for promotion expense, on the basis of $25 subscriptions per set of farm buildings, fire service to be free to subscribers during the life of the truck. At this meeting $800 was subscribed. The town had verbally agreed to house the truck and man it when in action in exchange for emergency use in the town.

Agents of fire-apparatus companies were sent for, the town fire chief was called in, and types of apparatus best adapted to fighting farm fires were thoroughly investigated. Three farm bureau members aided in soliciting subscriptions, but most of the work was done by a paid local solicitor. Soliciting was done in four townships within a 10-mile radius and was concluded in March, 1929, the $4,500 having been subscribed by 180 rural people, mostly farmers. Other farmers subscribed later.

The fact that many farmers had stock tanks was considered in selecting the type of apparatus. The chosen type cost $4,200, and was accepted after a test by the town fire chief. It is a combination pump and chemical truck with a 300-gallon booster tank. It has 30 feet of suction hose with strainer; hose body with capacity of 1,000 feet of hose; two 3-gallon hand chemical tanks with shut-off nozzles; one 60-gallon booster tank with 150 feet of booster hose; 3 searchlights, a siren, and the usual subsidiary equipment. The apparatus was built especially for country use and for handling water from pools or tanks. Dirty water can be used without damaging the apparatus, it is said.

A committee of farmers met the town fire committee to arrange regulations. At first the truck was given by the farmers to the town, but this brought the truck under the provision prohibiting town fire trucks from leaving the town. As the town was willing to operate the truck but did not wish ownership, the truck was returned. To simplify the minor questions of liability for damage to property or injury to persons in connection with the operation of the truck, the farmers found it convenient to incorporate under the State cooperative law for nonprofit organizations and thus retain the truck.

The subscribers formed the Boone County Rural Fire Corporation, the incorporation fee being $10. Seven directors were elected, and the head office was placed at the county farm bureau office. The only property owned is the fire truck.

Nonsubscribers outside the town must guarantee payments of $35 for the first hour and $25 for each succeeding hour for the service of the truck. Receipts from this source are available for needed equipment and maintenance. If the truck should be in use in the town when called to a farm fire, it would have to respond immediately to the farm call. The town has its own trucks. Until July 20, 1930, the truck had not been used in town but had answered 23 rural calls.

The county agent claims the following advantages for country service of the apparatus as compared with ordinary city apparatus: (1) It has a rotary pump that is not hindered by country water. (2) It is standard country width; city apparatus is wider. (3) It has road clearance. (4) It is both light and powerful for pulling through bad roads. (5) Booster-tank capacity is large, consistent with strength and safety. (6) It has large hose capacity, and often more hose is needed than in city fires. (7) It has more lights, including searchlights and spot lights. (8) Truck has regulation hose connection; if no water is available for suction, enough to keep a stream going can be carried by hand to the booster tank and suction can be made from a barrel. (9) Pump has a capacity of 350 gallons of water per minute when wide open but can be cut down to 10 to 15 gallons per minute. (10) It has the needed longer suction hose.

It was recommended that there be only a few solicitors for subscriptions, and that they be trained in rural-apparatus technic, and paid for their work of soliciting.

The town has a population of 7,804. The fire department includes six paid men, and there are four town fire trucks.

FARMERS ESTABLISH A FIRE DEPARTMENT WITH TWO BRANCHES, OAKDALE, CALIF.

The Oakdale Rural Farm Fire Unit, around a village of 1,745 people, resulted from the work of a group of farmers in a grain-and-stock-raising section in which grass and grain fires are a great hazard during the long dry season.

A rule of the town trustees made it difficult for the town apparatus to respond to out-of-town fires. An unsuccessful attempt to solve the problem had been made by the farmers by using an improvised fire truck. Group action had been educative, however, and in 1927 the farmers formed the farm fire unit.

After a study of the equipment needed it was decided to raise $4,000 to buy apparatus and to operate it one year with a paid driver continually on duty. An assessment of 4 cents per acre was agreed upon; 100,000 acres were included, and the $4,000 was subscribed by 60 farmers. A number of town business enterprises subscribed $2,000, making $6,000 available.

The apparatus first bought consisted of a 2½-ton truck with dual rear tires, carrying 500 gallons of water. On the front of the truck was a rotary pump running off the motor. Hose racks on each side carried 150 feet of hose and an extra set of hose was carried for building fires. Five knapsack or back pumps each carried 5 gallons of water. Other equipment consisted of three rakes, two shovels, two hand fire extinguishers, a fire torch for back-firing, cans for wet sacks, canteens for drinking water, and first-aid equipment. This truck was installed in Oakdale.

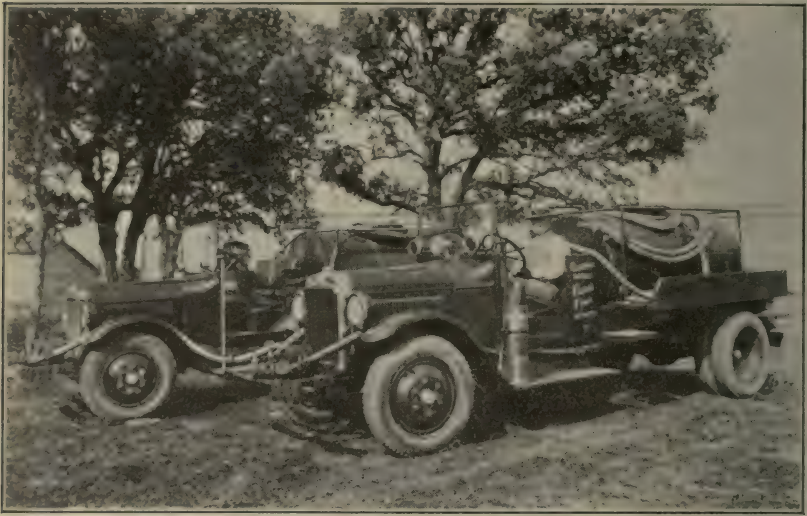

FIGURE 4.—The first two pieces of farmers' fire apparatus purchased and owned by the Oakdale, Calif., Rural Farm Fire Unit. The apparatus is manned at fires by their own fire department

A second similar truck was bought in 1928 and installed on a ranch 18 miles to the south. A worker there has the special duty of operating it. A third similar fire truck was bought in 1929 and installed in town, and the first truck was then placed in another section of the county. The original improvised truck is now a water wagon carrying 300 gallons of water in 10-gallon cans which can be dumped into the tank of a fire truck. The water wagon is used only at large building fires, since this is an irrigation district and all farmers also have stock tanks into which the hose from fire trucks can be plugged. The 500 gallons of water on the truck lasts 2½ miles of fire travel and is sufficient to put out the usual grass or grain fires. It is said to be enough for the average farm-building fire. In case of a large building fire the water wagon can be used, or the assisting farmers can refill the truck tank, by means of hose, from cisterns, pumps, etc. (Fig. 4.)

The fire unit bought 60 back pumps from the State and sold them to individual farmers. These are used to fight small fires, in follow-up work after a fire truck, and to install on harvesters.

The last two fire trucks were bought and one year's maintenance expenses were paid, through an assessment of 3 cents per acre. The only salaries paid are those of the town truck driver at $110 a month, two country drivers at $60 a month and board, and the fire chief at $400 a year.

The department was organized without regard to any particular fire law. The farmers own and operate the fire trucks; the town merely houses one truck in its fire house and allows the use of the electric call system there.

The farmers' truck is used at times in fighting town fires, under the supervision and management of its owners, for which no charges are made. It is claimed that effective work is done at town fires because the farmers' truck driver is the only driver on duty at the fire house and thus makes an early response and because it is not necessary to lay hose before beginning work on the fire.

The farm fire unit elects a board of five directors, each serving a year. A fire chief, who is appointed for a year, is manager of the department and goes to all fires with the driver. On account of the large number of grass and grain fires each year, all farmers are experienced in fighting such fires. When a fire occurs neighboring farmers gather and assist. A town fire brigade is at a great disadvantage in fighting such fires because it lacks the necessary experience and the proper kind of apparatus. Fruit farmers who have small orchards are allowed to become members of the organization at a minimum annual fee of $5. If they have over 300 acres they are assessed the same amount as are the large ranchers.

The department responded to 57 farm fires during the first 12 months and 48 the second 12 months. During the latter year there were 32 grass and 8 grain fires. Each year there were 10 building fires. The first year 240 acres of grain were lost but only 13 acres the second year. Grass fires are very serious. When one gets well started it may burn several thousand acres of grain. Losses were small in the latter year because experience had enabled the firemen to start quickly and to control the fire before great damage had been done. Efficient early action prevented a number of grain fires from threatening great losses during the long dry season.

This unit is recognized by authorities over the State as being very efficient. It is managed and operated by able and practical men. The Board of Fire Underwriters of the Pacific adopted specifications for a grass and grain fire truck based on the Oakdale farmers' truck.

The only apparent weakness in the system, is its possible lack of permanency as it is a voluntary association not organized and financed by taxation under the State fire district law as are many other rural departments of the State.

One of the sponsors and directors is a banker-farmer who operates a large ranch. He said:

> The system is splendid. Our truck can go into a big grain fire with the blaze 7 feet high and put it out as the truck goes along. Our truck went into another district, 16 miles distant, and put out a grain fire in a 1,000-acre field and lost only 15 acres. A man could hardly believe the fires we put out. All the farmers are well pleased.

The fire chief said:

> Our system works out 100 per cent. All the farmers are well satisfied. The truck surely does the work. If we had it to do over again we wouldn't make a change. We have been put in class A by the underwriters and have been allowed 25 cents per hundred reduction from the regular rates, on grain insurance. I believe that in five years 300 farm fire trucks will be in operation in California. The first five fires pay for the truck.

The representative of the fire underwriters said:

> The people of Oakdale like their system. It is good, but being a subscription rather than a tax system it may not be as permanent. We have reduced the grain insurance rates of these farmers on account of having this truck.

A COUNTY FARMERS' RURAL FIRE PROTECTIVE ASSOCIATION, ADRIAN, MICH.

Various agencies cooperated in the campaign for the purchase of a large fire truck to serve the farmers of Lenawee County. The grange officials, the local farmers' mutual fire insurance company, the county agricultural agent, the town fire chief, the welfare director, and local newspapers, and agents of the apparatus company all took part in promoting the enterprise. Farm fire protection had long been discussed in the local granges which also constituted a fertile field for the later work.

Formerly the town apparatus fought farm fires, but in 1922 this was forbidden. Leaders in the movement spoke in the local grange halls. It was decided to raise $9,500 by farmer subscriptions—enough to buy a large truck for country and for supplemental town use, and to cover the expenses of the campaign and leave a small balance. After a 3-month campaign during which 900 farm owners had contributed $9,500, the truck was bought in April, 1925. At the same time the Lenawee County Rural Fire Protective Association was formed and incorporated. New members were to be admitted on payment of from $20 to $200. Nonsubscribing farmers were to pay a minimum service fee of $100.

The large truck was practically made to order to meet the requirements of the fire chief. A committee of farmers and the fire chief visited the factory and inspected the apparatus before delivery. A 5-day demonstration test was made at Adrian before acceptance. A real test was made at an actual farm fire; the owner of the building was so well satisfied that he doubled his subscription.

The truck is a 6-tank chemical; each tank has a capacity of 35 gallons; the tanks are arranged in pairs, and it is possible to refill one pair while the others are working. The truck is equipped with three 200-foot lines of hose, 4 hand extinguishers, 24 extra chemical charges, siren, extension and roof ladders, axes, bars, lanterns, buckets, and mud hooks. It has a 6-cylinder motor of 75 horsepower. This truck was destroyed in a collision while on its way to a fire; the town of Adrian immediately bought a similar one for $7,000 and gave it to the farmers' association. (Fig. 5.)

The rural fire association elected its own officials, including a grange officer as president, and entered into an agreement with the town of Adrian, renewable annually, regarding the use of the truck. The farmers furnish and own the truck and are responsible for major replacements of damaged parts. The town department must house, care for, and operate the truck, furnish supplies, make minor replacements, give subscribers free service, and may use it for town fires, if precedence is given to country fires. In actual country use, the truck is manned by four town firemen. The apparatus is housed in the town fire house.

The following are the important provisions in the by-laws adopted by the rural fire association:

Article I. Name

Section 1. This association shall be known as the Rural Fire Protective Association of Lenawee County and shall be incorporated under Act 84, Public Acts of 1921, of the Laws of the State of Michigan, as amended. Its principal office shall be located in the City of Adrian, State of Michigan.

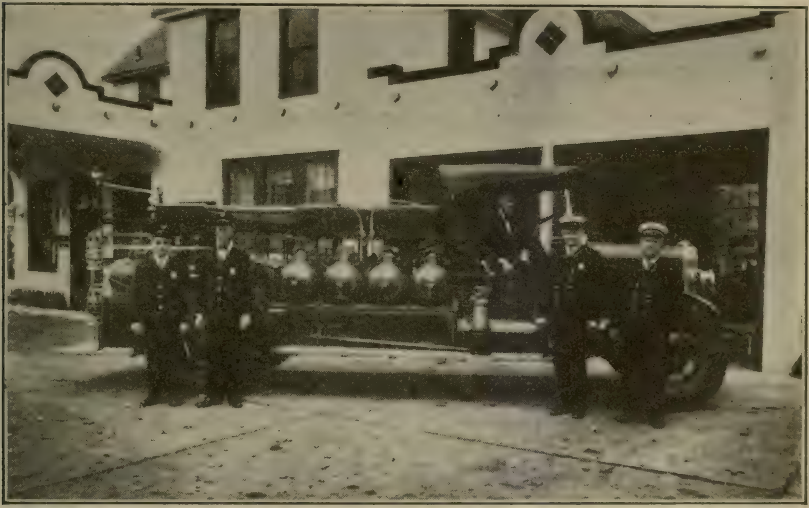

FIGURE 5.—Fire apparatus to serve farmers bought by the Lenawee County Rural Fire Protection Association, Adrian, Mich., which is composed of 900 farmers

Article II. Objects

Section 1. To buy, lease, or rent fire-fighting equipment, to be located in the City of Adrian and to be used for the protection of the property of its members, or others, as hereinafter provided.

Sec. 2. To buy, lease, or rent suitable buildings for the proper housing and care of same.

Sec. 3. The equipment of this association shall not be taken outside of Lenawee County, except by approval by the Board of Directors.

Article III. Membership

Section 1. After delivery and acceptance of Fire Truck, membership in this association shall be contributors of not less than $20 and not more than $200 and to have paid all assessments for the upkeep and maintenance of the equipment of this association.

SEC. 2. On the receipt of a contribution, the secretary shall issue a certificate of membership. Such certificate of membership shall not be transferable.

Article IV. Fiscal Year

* * * * * * *

Article V. Meetings

* * * * * * *

Article VI. Quorum (10 members)

* * * * * * *

Article VII. Officers

* * * * * * *

SEC. 5. The Board of Directors shall manage the business and affairs of this association, and make rules and regulations, not inconsistent with these bylaws or the laws of the state, for the management of the business and the guidance of officers, employees, and agents of the association.

Article VIII. Duties of Officers

* * * * * * *

Article IX. Rights of Members

SECTION 1. Each member of the association shall have only one vote; this shall not be exercised except when all debts and assessments owed by him to the association shall have been fully paid. Voting by proxy shall not be permitted.

SEC. 2. Any member upon written notice to the secretary may withdraw from the association at any time, but such withdrawal shall not affect any right or lien which the association may have against him. Any withdrawal shall be a forfeiture of benefits, right or contributions.

Article X. Audits

* * * * * * *

Article *XI. Charges to Non-Members*

SECTION 1. The charges to non-members for the use of the equipment of this association shall be not less than $100.00 for each call, or as determined hereafter by the Board of Directors.

Article XII. Amendments

* * * * * * *

Since the truck was bought 32 new subscribers have joined the association. Withdrawals, deaths, and removals left the 1929 membership at 850. The association had a balance in its treasury in 1929 of $600. It has never had to make an extra assessment. Each of the two previous years it contributed $100 to the firemen's fund. Difficulty is found at times in collecting fire fees of nonsubscribers. The annual cost of supplies for the truck has been $150, and total repairs have cost $100 annually. The town department has 16 paid men, including the chief. Two men were added when the farmers' truck was bought.

Most of the farmers have telephones, and fire calls are transmitted free. There is a bell in the fire-house tower. Farm fire-call signals differ from town fire-call signals.

During the nine months' use of the truck in 1925 there were 23 farm fire calls; in 1926, 32 calls; in 1927, 28 calls; in 1928, 28 calls; and in 1929, 23 up to October 5. The truck has made an excellent record in saving farm property. If given an early call it usually saves the major portion of the burning building and nearly always the adjacent buildings. The chief is especially energetic in farm fires and in encouraging fire prevention.

Grange and farmers' insurance officials claim an especially low farm-fire insurance rate for the country districts, giving to the truck a share of the credit. The president of the rural fire association put it this way: "Buying this truck has done more good than the truck itself. It keeps down the insurance rate."

The secretary of a farmers' mutual fire insurance company wrote, in response to inquiry:

> Officers of this company know that the truck has saved their company thousands of dollars and that during the present depression in land values, when farms are selling for the value of the building—and sometimes less—if it had not been for services of the rural truck we would surely have a higher rate than $3 per $1,000 for the last three years.

The secretary of the farmers' association concluded:

> After a careful survey of each fire occurring during 1926 and 1927, it was my estimate that the rural fire protection service saved the farmers of Lewanee County $42,000 worth of property in 1926 and $26,000 in 1927.

FIRE-DISTRICT FIRE DEPARTMENTS

The demand for farm fire protection and the growth of rural fire departments has resulted in the enactment of laws in a number of States enabling the formation of rural fire districts. Rural fire departments are being organized in a number of States, according to these laws. These districts generally center about a rural village and include farming territory; but they may consist of all the farming territory around, but excluding the village as at Mountain View, Calif., and may include parts of more than one county. They sometimes include several towns. The districts form their own fire departments, although in some cases they may contract for service from a neighboring fire company. The building of fire houses and purchase of apparatus is financed by taxation and the district may borrow money and receive donations.

The departments are generally intended as a solution of the farm fire problem; the primary work of the fire department is fighting farm fires. Among the States that have passed some kind of fire-district law are New Jersey, New York, Illinois, Oregon, Rhode Island, and California. California has made the most progress; 24 of its districts have been recognized by the insurance underwriters and given reductions in grain-insurance rating. Their principal characteristics are organized fire districts, fixed territory, and taxation finance. Their legal form tends to give them permanency. Some have completely organized fire departments, and some have the nucleus of a department but depend partly on volunteers for fire fighting. The latter are known locally as unorganized departments.

A RURAL FIRE DISTRICT WITH UNORGANIZED FIRE DEPARTMENT, ELK GROVE, CALIF.

The Elk Grove fire district is 8 by 9 miles in dimensions, with an area of 72 square miles. The initial impetus for the organization of this rural fire district, centering in a village of 475 people, was the desire of the chamber of commerce to draw ranchers into its membership.

Ranchers had been suffering great losses from grain fires, which they had been fighting by the usual wet-sack hand method, and they were seeking fire protection. Sixteen members of the chamber went out among the ranchers in May, 1925, primarily on a membership drive, incidentally taking a petition to organize a legal rural fire district. The chamber of commerce gained four new rancher members, and the ranchers and the village people formed a fire district.

The ranchers were practically unanimous for the fire district. Eighty ranchers, representing 40,000 acres, signed the petition, which was presented to the county board of supervisors, who called an election in the proposed district to determine if a district should be formed and a tax levied to purchase and maintain fire-fighting equipment. The election was held on July 3, 1925, and the motion was carried practically unanimously. The board of commissioners of the fire district set the financial requirements for the first year, ending June 30, 1926, at $4,500. Meanwhile, a petition was received from other ranchers to come in, and 35 more ranchers, representing 19,000 acres, were included in the district.

The district has acquired three pieces of fire apparatus, two stationed at Elk Grove and one at Franklin, 7 miles distant. The principal piece at Elk Grove consists of a pumping engine and a 450-gallon water tank mounted on a substantial truck with dual rear wheels. The pump is driven direct from the transmission. Equipment includes 400 feet of 1½-inch hose, 400 feet of ¾-inch hose, eight 2½-gallon hand extinguishers, searchlight, siren, 4 steel fire rakes, four 5-gallon knapsack pumps, 3 axes, 6 shovels, pipe wrenches, spanners, hose adapters, 1 extension and 1 roof ladder, and a first-aid kit. The second apparatus at Elk Grove consists of a truck with two 45-gallon chemical tanks, 400 feet of 1-inch chemical hose, 2 small hose carts, 1,200 feet of 2½-inch fire hose, and a 24-foot extension ladder. One of the hose carts is attached to the rear of the truck and is instantly detachable. The apparatus at Franklin is a truck with four 35-gallon chemical tanks, 400 feet of 1-inch chemical hose, 1 extension and 1 roof ladder, 4 acid and 4 soda receptacles, and twelve 2½-gallon extinguishers, 2 axes, and 4 shovels. A supply of soda and acid is kept at each station.

The district does not have an organized fire department, as there are few young men in the town. A paid driver and a volunteer fireman at each place do most of the fire fighting, assisted by volunteer helpers.

The district elects four fire commissioners who elect, from among themselves, the usual officers. The commissioners also select a district fire chief. Each driver is paid $40 per month for the four fire-hazard months, but they serve the whole year. The pieces of apparatus are employed largely in grass and grain fires but also in building fires. The ranchers have had much experience with grass and grain fires and flock to a fire to assist. The Boy Scouts also help. One good fire fighter to handle the truck and two to handle the hose line are the principal fighters needed. The men stand on the running board and turn on the hose, which can throw a 60-foot stream, while going an average speed of 4 to 5 miles an hour.

The equipped pumping engine at Elk Grove cost $4,700. The chemical truck cost $47 for assembling, the parts having been donated. The hose carts with hose cost $800, making a total cost of $5,545 for all the fire equipment at Elk Grove. The apparatus is housed in an engine house that cost $560 to build. The Franklin apparatus cost $4,500 and is housed in a $460 building.

All the apparatus was brought through taxation, the district having $3,333,333 worth of taxable property. The first assessment to cover the first engine and two years' operation and the engine house was 18 cents on a hundred dollars. In 1929 the assessment was 20 cents on the hundred, for the purchase of the Franklin apparatus and one year's operation of all apparatus. This includes all expenses since the district was organized up to the time of this study. The district had no debts and had $455 on hand August 14, 1929. The assessment for 1930 was 5 cents on $100, producing $1,500—more than enough for contemplated expenditures.

The department responded to 133 fires in 1927, to 58 in 1928, and to 74 in 1929. The fires were nearly all rural and were mostly grass and grain fires. Most of the fires occurred during the four summer months of dry weather. Forty-three per cent of the fires in 1929 were outside of the Elk Grove district.

P. B. Smith, who lives 3 miles from town, told of his barn fire:

> My fire occurred at 3 o'clock in the morning. The barn was filled with hay. When I saw the fire, the roof and the top of the hay were ablaze. Several buildings, machinery, and a fence soon caught fire. Five minutes after the telephone call the fire truck arrived and only the barn burned. The fire department does extra good work. They have saved thousands of dollars worth of property. No doubt we have saved the insurance companies more money than we have saved ourselves. Taxes are nothing to what that machine has saved. We have as good a chance of saving our house as a house in the suburbs of Sacramento would have from their trucks.

The representative of the fire underwriters said:

> This is a good example of a rural fire district with an unorganized fire department. We have allowed these people a decrease from their regular rates in fire insurance rating on growing grain and grass, on account of the formation of this fire district and the good fire-protection work done.

A RURAL FIRE DISTRICT WITH ORGANIZED FIRE DEPARTMENT, ARBUCKLE, CALIF.

The rural fire district at Arbuckle, Calif., is said to have been organized as a result of an implied understanding that if a district were formed and if apparatus acceptable to the underwriters were bought, the underwriters would allow a reduction in fire insurance rates on standing grain. The State school of agriculture had already prepared specifications for such a truck at the request of the underwriters. Both the farmers and the insurance companies had suffered heavy losses and both were looking for relief. The insurance people believed that the organization of legal rural fire districts would be to their advantage; the farmers wanted insurance reduction and fire protection.

Arbuckle, a town of 1,533 inhabitants, had a volunteer fire company, organized in 1915. They had motorized chemical apparatus, bought in 1915, for fighting grain and grass fires; 50 people, including 25 farmers, had subscribed for its purchase. They concluded that an organized fire district with an organized fire department and modern apparatus, all supported by public taxation, would meet the situation better.

Three farmers and the fire chief conducted the campaign for forming a fire district. At the general election for the formation of such a district, held in November, 1928, the proposition carried, and a petition for such formation was sent to the county supervisors, who approved it January 1, 1929.

The district contains 81 square miles, with Arbuckle approximately in the center. The property valuation was approximately $4,500,000 in 1929. The crop acreage in the district is about 60,000; grain acreage accounts for 60 per cent and orchards and vineyards cover the remainder.

Water is limited, and this is one of the difficulties in fighting the fires, but many farmers have storage tanks. Water can generally be found within 2 or 3 miles of grain fires.

In August, 1929, the district had three pieces of fire apparatus. The main one was a truck with low gears, carrying 400 gallons of water. Mounted on the truck was a high-pressure pump, driven by a 20-horsepower motor. Other equipment consisted of 200 feet of 1½-inch hose with ½-inch and ⅝-inch nozzles, 400 feet of high-pressure hose with small nozzles, 30 feet of suction hose, 6 knapsack pump tanks, 6 rakes, 6 shovels, wire cutters, electric hand lanterns, searchlight, wire broom, a towline, and first-aid equipment. The second piece of apparatus was a truck with a pump and a 350-gallon tank with somewhat similar equipment. It was used for supplying water to the first, but could be used for a fire direct. The third was a truck equipped with two 40-gallon chemical tanks. It carries 100 gallons of water and a hand-operated force pump. Minor equipment is similar but less than in the case of the others. This truck was used for oil fires or in emergency cases. Each of the three trucks was used for building as well as grain and grass fires.

The first or principal truck was bought May 1, 1920, and cost $4,662.70, paid for through district taxation. The truck cost $2,562.70 and the equipment $2,100. The second and third trucks were old trucks that the Arbuckle fire department had bought through public subscription. The second cost $1,785 and the third, $800, excluding some salvaged equipment. It was estimated that maintenance and operating expenses would be $2,000 the first year.

The first two trucks are housed in the Arbuckle fire house, formerly bought through public subscriptions. The third truck is kept in College City, a village 3½ miles distant. The driver there picks up men on the road as he goes to a fire.

The fire-alarm siren, driven by a 5-horsepower motor, can be heard several miles away. Most farmers have telephones, and alarms can be turned in from any telephone in the district.

The Arbuckle fire department is well organized and now consists of 26 local men, all volunteers. All are unpaid, except the chief, who receives $150 a month for the five fire-hazard months, although he serves by the year. The district is governed by a board of five directors, all farmers, appointed by the county board of supervisors.

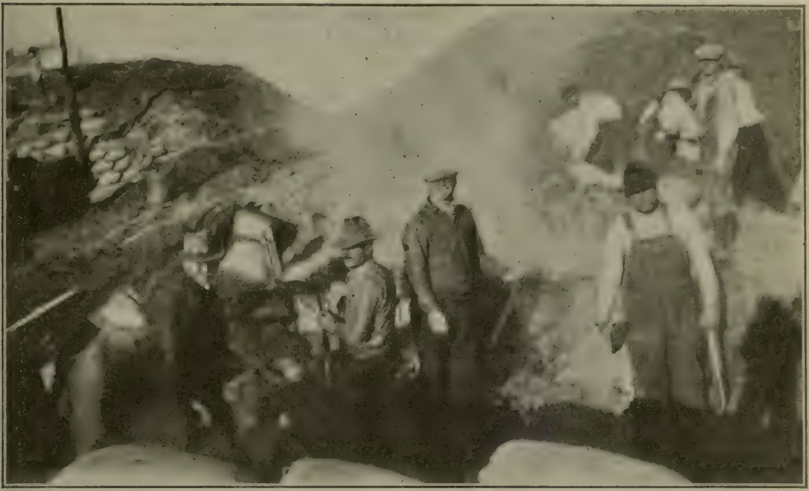

FIGURE 6.—Fire department of the Arbuckle, Calif., rural fire district fighting a fire in grain piled outside a local elevator

The number of fires attended, from May 1, 1929, when the district truck was bought and the date the hazard season begins, to August 14, 1929, was 22. Of these, 11 were grain, 5 grass (generally in grain stubble), 2 buildings, and the others minor grass and fence fires. The largest grain area lost was 25 acres. The largest number of firemen to report for a fire was 25, the smallest 6. About 75 per cent of

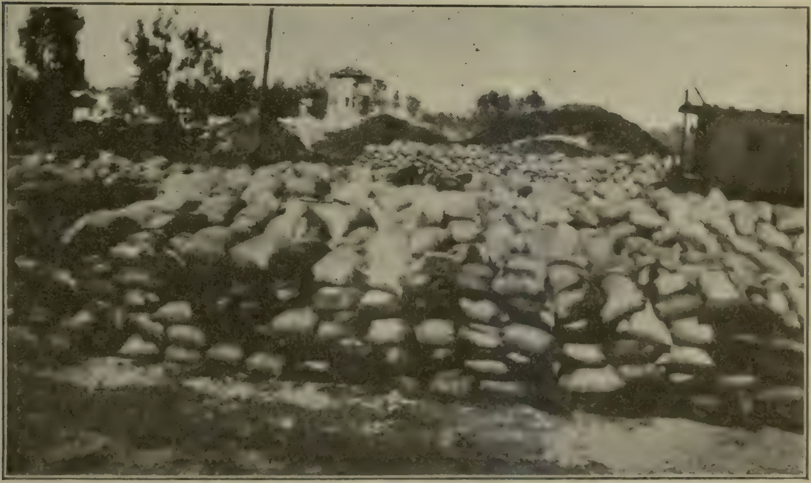

FIGURE 7.—Bags of grain salvaged in the fire shown in Figure 6

all fire calls since the department was organized have come from the country. (Figs. 6 and 7.)

The 25 acres of grain burned was on the Pryor farm 5 miles from town. It was in a field of 1,000 acres, and according to the fire chief, all would have burned if the truck had not gone to it.

The district was one of those in which the insurance underwriters allowed a 25 per cent reduction from the regular rates of 1929 on growing-grain insurance. The assistant fire chief estimated that this would result in a saving of $13,000 to growers, as compared with what had been paid in previous years.

As to a fire on the West farm, 8 miles from town, Byron Hughes, at the place, said:

> The fire department service is wonderful. The truck got here quickly. Mr. West's harvester and 132 sacks of barley burned, but it saved 320 acres of barley of a near neighbor. The fire burned 5 acres of my stubble and would have burned 200 acres if the truck had not come. The stubble is worth $2 per acre as feed for sheep.

COMMUNITY FIRE DEPARTMENTS

The largest number of fire departments organized to aid farmers come under the classification of community fire departments. In this class, country people and townspeople unite in financing fire departments or pieces of apparatus. In small towns the fire company is often common to both country and town. In larger towns, especially if objection is made to the town apparatus leaving to fight farm fires, one or more pieces of apparatus are bought especially to serve farmers.

In this class the greatest number of methods of financing occur, including combinations of individual voluntary country and town contributions; contributions by farmers' mutual insurance companies, town fire departments, and country and town industries and organizations; town, township, and county appropriations; and receipts from carnivals and entertainments, usually given by fire departments.

The primary aim is fighting country fires. Ownership of apparatus is vested in the town and country fire associations, the town, or the fire company. If the fire apparatus is owned by the town, country people generally have an agreement with the town, preferably written, that the apparatus will also serve country people.

A RURAL FIRE DEPARTMENT FINANCED BY FARM AND VILLAGE SUBSCRIPTIONS, DURAND, ILL.

The Durand Community Fire Department in Illinois is the result of the efforts of a farmer member of the local farmers' fire insurance company and a village dentist. Durand was a typical country village of 549 population without water mains or efficient organized fire protection. As a result of former farm losses, many of which might have been greatly lessened by the use of good equipment, premiums on farm fire insurance were becoming very high.

A proposition before the people of the village to install water mains had been defeated. In 1924 a serious fire in the village burned a church, store, office, and dwelling. The whole village might have burned had not a fire department 20 miles distant come to the rescue.

Shortly after, a farmer lost all his buildings in a fire. In all, about $75,000 damage was done.

The member of the farm fire insurance company and the village dentist thought that such losses could be prevented or greatly curtailed by an organized local fire department with proper equipment. The village had no funds for the purchase of effective apparatus, so the community fire department was thought of as a means of obtaining apparatus by public subscription, the funds to be solicited from as many farmers as possible.

The village had agreed to house and maintain the apparatus for the use of it within the village. A meeting of leading farmers was called and the idea explained. The farmers were favorable. Officers and a purchasing committee were elected. Other meetings were held, a map was made of the community within a radius of 6 miles and a representative of an apparatus company was called in. The community was divided into six districts, each with a list of property holders, and a solicitor was appointed for each district.

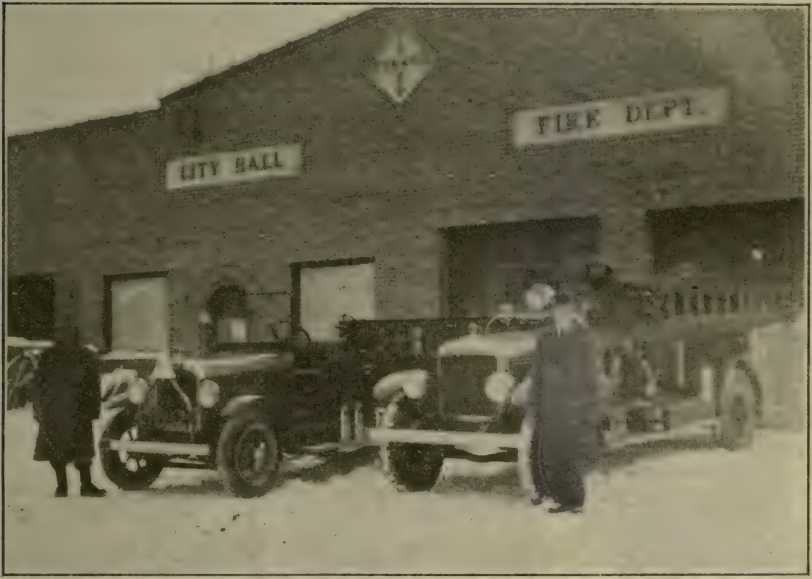

FIGURE 8.—Fire apparatus bought by the Durand, Ill., Community Fire Department, composed of 300 farmers and 158 villagers

They first set $6,000 as the amount needed but later decided to buy a second apparatus. Each contributor signed a contract to pay a minimum of $15 (providing $6,000 should be raised) and have free fire service during the life of the truck, the town to house and maintain the apparatus according to written agreement. The individual contracts included individual notes which were deposited at the bank, subject to purchase of apparatus.

The total sum needed was finally set at $10,500. There were $5,000,000 worth of buildings in the district in need of protection. When $9,000 had been subscribed the two sponsors signed personal notes for the remaining $1,500. Later subscriptions with a $25 minimum repaid this amount. The $9,000 represented the subscriptions of 300 farmers and 158 village people; 90 per cent of the farmers had subscribed. The total number of subscriptions later reached 500, and subscription lists were closed. A fire fee was agreed upon for those farmers not subscribers, $35 for the first hour and $25 for each additional hour.

Two pieces of apparatus, a pumper and a chemical, were bought in June, 1925. (Fig. 8.) The pump and chassis of the pumper were purchased at one factory; the truck was made according to submitted specifications and cost $6,800, equipped. It has a 16-inch clearance and is equipped with two 70-gallon tanks, a 75-horsepower motor, 1,000 feet of 2½-inch fire hose, 400 feet of 1-inch hose, 30 feet of 4-inch suction hose, 40 feet of 1½-inch suction hose, a 45-foot extension ladder, 12-foot roof ladders, two hand fire extinguishers, nozzles, tips, and similar accessories. The pump was run from the motor that drives the truck.

The pumper throws a stream 110 feet high at the rate of 500 gallons a minute. The capacity can be cut from 500 gallons to 16 gallons per minute so that the water can be forced through the ¼-inch tip of the 1-inch hose and the water thus conserved. There is a large opening into the water tanks and in case there is not a sufficient supply of water at the fire a bucket brigade can be formed to pump water into the opening.

By using the 1½-inch suction hose, water can be taken out of a well or stock tank without stopping the pump. On the recommendation of the fire chief a number of farmers built reservoirs, separate from buildings, in which from 300 to 400 barrels of water, from the eaves or pumps, is always stored.

The second apparatus carried two 45-gallon chemical tanks so arranged that when one tank had been emptied the other tank could be used while the empty one was being recharged. It had 200 feet of chemical hose, ladders, and minor equipment, and a speed of 60 miles per hour. This apparatus cares for the smaller fires and cost $3,700 equipped.

The town houses the apparatus in a new brick fire house, 24 by 40 feet in dimensions, and keeps a watchman always on hand.

The subscribers organized the Durand Community Fire Department, which owns the equipment, and in 1929 it had over 500 members. The members annually elect a board of trustees and the usual officers. A volunteer fire-fighting company of 28 members was organized and trained. This is an organization of the village of Durand. The village also appoints a fire marshal. Three firemen are trained for each duty; if a fireman is to be away from the town he must notify his substitute. Every man is said to know Shaefer's method of artificial respiration, the fireman's lift, how to carry people down ladders, and how to tie the various knots in ropes needed to do this. They also know something of the science of hydraulics and the friction laws of fire hose.

After each fire a printed slip of 38 questions is filled in by each fireman and is countersigned by the captain. The questions concern the kind of fire, time, cause, how extinguished, kinds of equipment used, amount of damage, names of the firemen, etc.; they concern the care of the apparatus and of each piece of equipment after a fire, and the preparation of the apparatus for immediate use for the next fire.

A complete fire survey was made of the whole district. A map was prepared and hung in the engine house showing conditions of roads, location of buildings, gates, and water supplies, and other information. A card-index system was installed, listing all subscribers. Each card carries a subscriber's name and a drawing showing the location of buildings, chimneys, oil barrels, and the location and amount of water supply. When the chief goes to a farm fire he carries the card for that set of buildings.

One fire insurance company in another town keeps a renewable amount of money in the treasury of the Durand department to guarantee the expenses of runs made for the benefit of their policyholders, all of whom live outside the zone of the Durand department. This sum of money has been twice exhausted and renewed.

On July 5, 1930, the department had responded to 108 alarms, 102 of which were for fires on farms.

The farmer sponsor and member of the local mutual fire insurance company said:

> Previously farm insurance losses had been very high. Premiums every year had amounted to several times what fire protection now costs. The community apparatus has reduced premiums. This would apply to any community with a fire department properly manned.

The other sponsor of the fire department, who has charge of the fire-fighting company, and who has had much experience in a farm fire company and in giving advice to other rural companies made the following recommendations on the general subject.

> Before organizing a department and buying rural apparatus it is well to consult officials of organized and successful rural fire departments.
>
> Only such apparatus should be bought as is adapted to rural conditions and to the particular community to be served. The usual city apparatus is not suited in many ways to serve farm fires. Some of the best apparatus companies now make specialized types of rural apparatus.
>
> Before buying apparatus, bids should be obtained from several companies and representatives should be invited to conferences. Careful consideration should be given bids. Many companies have only standard city apparatus.
>
> A $1,000,000 apparatus, if not properly manned, is not worth much and the apparatus must be continually inspected and kept in good condition.
>
> Fire fighters should be trained, especially in rural conditions; they can be fairly well trained in 30 days' time by instruction, practice, and demonstrations, if several fire runs are included.
>
> A community fire department is useless unless it has an efficient organization and it is necessary, by various means, to keep up the interest of the members of the department.

He concluded: "No investment ever made by any of our subscribers has shown such a net return. The cost is little—the protection worth while."

A RURAL FIRE DEPARTMENT AT BERNVILLE, PA.

Bernville, a village with a population of 302, is the center of a rural community whose "fire company," which includes 322 members and 26 volunteer firemen, owns two pieces of motorized apparatus and a $40,000 combined fire and community house with moving-picture machines. The fire company and its community house are financed through voluntary efforts of country and townspeople. Free fire-fighting service is given to the village and to all farmers within a radius of 6 miles.

Bernville Community Fire Company No. 1 was organized in 1920. The officers, elected by the membership, consist of president, vice president, recording secretary, financial secretary, treasurer, 3 trustees, chief, assistant chief, engineer, first and second assistant engineers, 6 nozzlemen, 12 hook-and-ladder men, delegate to the firemen's union, and janitor. All officers serve one year except the trustees, who serve 3 years. The local minister is president of the company, and the secretary was a farmer when elected. The membership fee is $1 per year.

The fire-fighting team of 26 members has an executive committee of 3 members (consisting of the chief, assistant chief, and ladder chief) and is under the immediate orders of the chief. The apparatus and fire house belong to the company, and in case the company suspends or dissolves, the apparatus reverts to the village, to be turned over to a new community fire company, if such should be organized.

The fire apparatus consists of a 250-gallon pumper with 1,600 feet of 2½-inch hose and a chemical apparatus with dual shifts, two chemical tanks, and 200 feet of hose. (See cover picture.)

The pumper, bought in 1921, cost $3,900, and the hose cost $1,600. The chemical outfit, bought in 1922, cost $680 (the 1-ton chassis cost $480, the hose $65, and the tanks were donated). In 1929 a new 1½-ton chassis with 4-wheel brakes was bought for the chemical for $685, and $1,100 was spent in overhauling the engines and for purchasing pneumatic tires to replace the solid tires on the pumper. In all, nearly $9,000 has been spent on apparatus.

The building, owned by the fire company, was built in 1922 as a fire house and community building. (See cover picture.)

The building is a 2-story brick structure, 42 by 120 feet in dimensions, and has a 7-foot basement. It is heated by steam and lighted by electricity. On the first floor is an auditorium, used for community purposes, with chairs seating 396 people, and a large stage. The auditorium is ventilated by two electric exhaust fans, the combined cost of which was $300. In the rear is a moving-picture booth with asbestos lining. At one side is the fire-apparatus room opening on the street. On the second floor are two large social rooms, a hall 42 by 78 feet, an equipped kitchen, and toilets. The fire house has a bell and a siren, costing $500, which can be heard a distance of 4 miles.

In 1925 two second-hand moving-picture machines were replaced by two machines that cost $1,400. An allowance of $260 was made for the old machines. Good films are bought from the leading film supply companies about one year after their first appearance. The agreement is that the fire company may choose the film; if a poor one should be substituted by the supply company it may be returned.

At first music accompanying the films was furnished by a piano, but in September, 1929, an electrograph with loud speaker was bought for $700, including 250 double-life records. In the picture booth are two modern projectors, each costing $700 in 1927.

No charges are made for the use of the social rooms by organizations. The second-floor hall is rented for various uses. The auditorium is used for community occasions without charge.

The two pieces of fire apparatus and the fire-community house were paid for through the usual entertainments, and through voluntary contributions of farm and village people. In financing the fire house the fire company issued $6,600 in bonds and redeemed them in seven years.

In January, 1930, the only debt was $400 for the electrograph. There was $119 in the treasury. Fire service is without cost, but contributions of $40 or $50 are sometimes received from those served.

Weekly street carnivals are held during midsummer and weekly indoor fairs are held in the fire house for six weeks during midwinter. During recent years moving pictures have been taking the place of carnivals and fairs as revenue producers. From 1920 to 1929, inclusive, the profits from outdoor carnivals were $22,960.73; from indoor fairs, $9,409.94; and from motion pictures, $10,083.20.

Over $2,000 was received through contributions for the purchase of apparatus from some 200 farm and village contributors. Farmers donated labor to the value of $457 in constructing the fire house.

The operating expenses of the company have averaged $1,400 a year. Included in the expenses are: Coal, $336 per year average; electric lights, $192 per year average; operator of moving picture, $5 per night; musician, $4 per night; janitor, $25 per month; recording secretary, $50 per year; financial secretary, $20 per year; treasurer, $10 per year.

The fire company has a separate voluntary relief association of 156 members, with its own by-laws. The membership fee is $1.50, and there are no dues. When a member dies each other member must pay $1 to the relief fund; the deceased member's estate thus receives about $150. This arrangement is in effect as long as the membership is below 175. Since the association was organized in 1926 it has spent $1,025 for death benefits involving eight people.

The three townships and the village which comprise the territory of the company are paying about $90 per year for liability insurance covering its firemen under the State compensation law.

Fire-prevention week is observed each year. During the 1929 week the president of the company gave talks at 12 schools. The company always sends representatives to the county firemen's training school.

The company uses social agencies in maintaining its morale. Its women's auxiliary aids at carnivals and fairs, attends the sick and injured, and organizes social events. An annual banquet with several hundred in attendance is held in the fire hall each winter. Addresses are made, and there are free moving pictures. The preparations for the annual carnivals and fairs serve as an integrating social force. In May and October there are county conventions in rural towns. Delegates are sent to regional and State conventions. The large, well-arranged fire hall and community house is the most effective social instrumentality.

The company instigated the purchase of a 5-acre park which was later turned over to the village. Committees were appointed, subscriptions obtained, entertainments given. A pavilion, a refreshment stand, an artesian well, and roads and bridges were provided. This project cost the community $5,000 and is paid for.

From 1922 to 1929, inclusive, the company responded to 52 fires. Of 38 of these fires during five years, 28 were on farms; separate figures were not kept during three years. From 4 to 10 firemen accompany the apparatus to fires; from 25 to 50 go in their own automobiles.

Relative to his barn fire, Mr. Kramer, 4½ miles from town, said:

> The fire occurred at midday when the workers were in the fields. Children were at the barn playing with matches. Within 20 minutes after the fire was noticed the apparatus had arrived and many firemen were fighting it. The barn, valued at $4,000, burned, but other buildings 30 feet away were saved. The fire company did very good work.

The pastor president of the fire company was enthusiastic as to the success of this enterprise, and his opinion was representative of the opinions of farm and village people. He thought that perhaps the greatest result was the fine community spirit engendered not only through creating the company, purchasing the apparatus, and erecting the fire house, but through promoting other civic and religious endeavors. There has been an indirect benefit to schools, churches, and other organizations.

Many people who seldom came before come to town to see the moving pictures and enjoy the entertainments in the community house with resultant advantages to local business and organizations. The fire company has taken the lead in the promotion of good roads. The movement for the construction of one 6-mile piece of concrete road costing $240,000 was originated by the fire company. The community hall was given free for the road meetings.

RURAL FIRE SERVICE FINANCED BY NINE TOWNSHIPS, MEDINA, OHIO

Medina, Ohio, a village of 3,430 inhabitants, is in two townships, and adjoins two others. Its community fire apparatus gives protection to these and seven other townships. If called, the fire company does not hesitate to go outside of these townships.

Supplementing the Medina village apparatus, a small chemical outfit was bought in 1916 through contributions of village and country people; it was used largely in country service. The experience of the chief of the department with this apparatus, which saved considerable farm property, convinced him that much more could be done with better apparatus.

He had been among those who had supposed that a water pumper would not be serviceable in the country because of lack of water. He became convinced that this was not true and determined to obtain a modern pumper. He enlisted the aid of farmers and newspapers. A group of farmers who had been at a farm fire where considerable property was saved by the small chemical, believed that much more could have been saved by better apparatus. They offered to back the chief in his campaign. The chief made a rural speech-making tour, committees were appointed, and farmers and firemen joined in securing subscriptions.

Business men of Medina subscribed, for three reasons: (1) Reduction of farm fire losses would enhance the prosperity of farmers and make them better customers of village business men; (2) good will engendered among the farmers would improve town and country cooperation to mutual advantage; and (3) village people would have an emergency piece of fire apparatus.

The village firemen realized $700 from benefit entertainments to obtain money for the community apparatus. Three hundred rural people gave $3,000. All but two village business men subscribed and $2,000 was raised. Thus $5,700 became available.

The apparatus, bought in 1925, is a 400-gallon water pumper equipped with two 40-gallon chemical tanks, 1,200 feet of ordinary hose, 300 feet of chemical hose, 40 feet of suction hose, a 1-gallon chemical extinguisher for electrical fires, two ½-gallon extinguishers, a 2½-gallon extinguisher, a 36-foot extension ladder, a 14-foot roof ladder, and the usual accessories, together with clothing for firemen.

There is no written agreement, but it is understood that the community apparatus is under the control of the Medina volunteer fire department. This arrangement was made in order that there might be no restraint in its use for country fires or as subsidiary apparatus for village fires.

There is an understanding that the village will pay the salary of the fire chief, in charge of both town and community apparatus, and the principal maintenance expenses; the fire department is to care for the minor ones. The apparatus is housed with the village apparatus in the village hall. After the pumper was bought the small chemical was sold to another village. From 6 to 10 firemen accompany the apparatus to country fires, for which they receive pay. Others that go are not paid.

To help maintain the apparatus, provide for depreciation, buy new equipment, and pay the service of firemen at rural fires, a charge plan was arranged for rural fire-call service.

The average service charge for farm fires in 1927 was $52.50.

The Medina volunteer fire department consists of 26 men, including 1 chief and 3 assistants. The chief receives a salary of $200 per year and the chief engineer, who cares for the apparatus, $15 per month. All firemen receive pay for service at fires. (Figs. 11 and 12.)

The chief emphasizes training and discipline in the department. Once a month he holds a school for firemen. Fire drills and contests are held regularly in summer. The firemen are divided into fire troops, and each troop is graded on skill, speed, movement, and knowledge of the work, a prize being awarded to the winning troop. As a result 18 men, besides the salaried men, can drive and operate either of the trucks.

An alarm system has been installed at a cost of $900. In the home of each fireman is a fire bell on a special telephone circuit, and alarms are transmitted through the telephone exchange, the central operator transmitting the name of person, location, road, etc. There is a large fire bell on the fire house that rings different signals for farm and town fires.

The department experiences little difficulty in obtaining water for farm fires. Cisterns, wells, ditches, creeks, and ponds are used. (Figs. 9 and 10.) Water can be pumped 1,200 feet if the apparatus can come within 30 feet of the water. As an experiment in the village, water was taken from a cistern, pumped through 1,000 feet of hose with a pumper to another pumper which was also used as a booster, and the water was pumped through 1,200 feet more of hose and played on a building. (Figs. 11 and 12.)

The department keeps a careful card-record system of information concerning each fire. An attempt was made to compute the amount of rural fire losses and the value of property saved in fires for which runs had been made. During 1927, two appraisers, chosen from insurance men, contractors, or bystanders, aided the chief in the appraisals of each fire. During that year 45 runs were made to build-

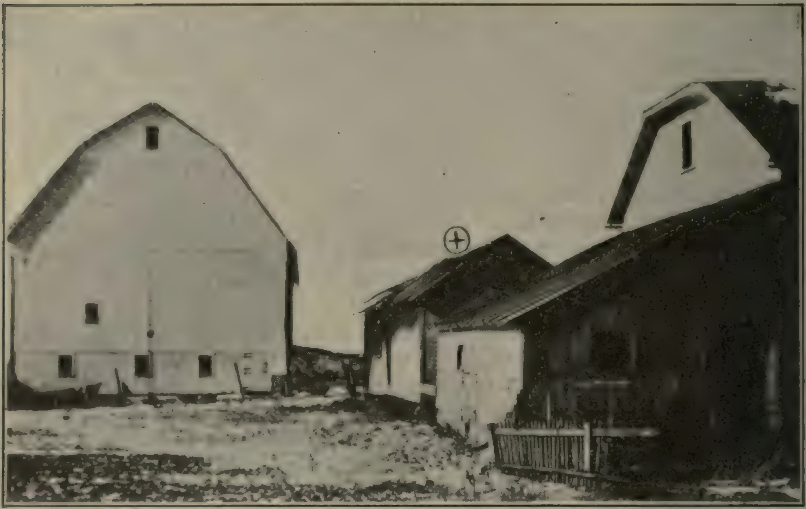

FIGURE 9.—Aftereffects of a fire on the D. Winch farm, 5 miles from Medina, Ohio, fought in below-zero weather by the Medina community fire apparatus. Water was secured from a cistern. Estimated value of buildings saved, including house, $16,000. Fire damage, $400. A cross (x) marks the shop building where fire originated

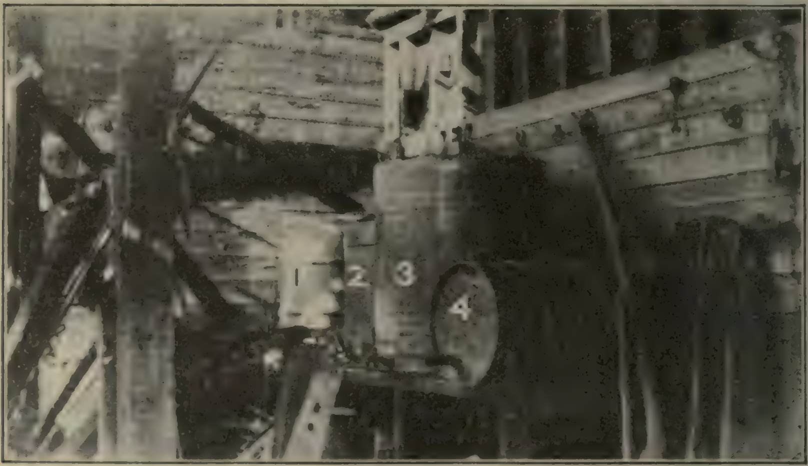

FIGURE 10.—Interior of shop building after the fire (fig. 9) was controlled. Drum No. 1 contained 50 gallons of gasoline; No. 2, 25 gallons of crank-case oil; No. 3, 65 gallons of kerosene; No. 4, 20 gallons of lubricating oil

ings endangered by fires on farms or in unprotected villages. The total value of the buildings, exclusive of contents, was $210,000. The total loss by fire was $50,000, and the value of the property saved was $160,000. In 1928 there were 31 runs; the value of the buildings involved was $85,000, the loss was $28,000, and the value of the property saved was $57,000. The number of runs in 1929, up to October 2, had exceeded the total for the whole year of 1928, and the total value of the buildings was higher.

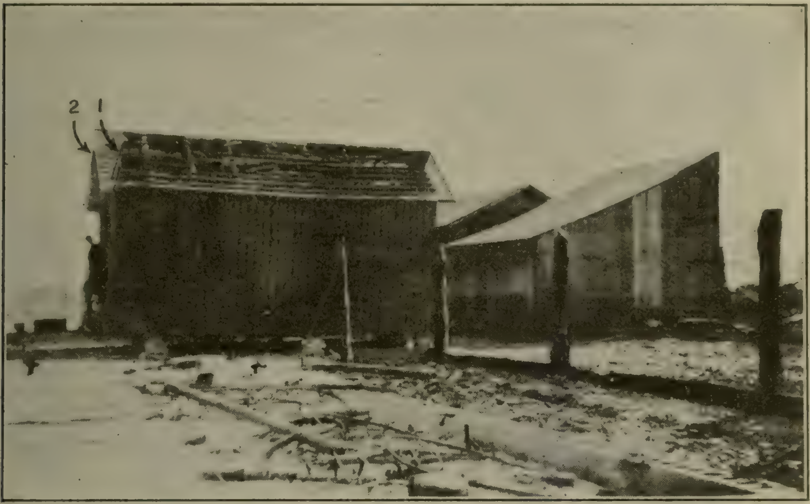

FIGURE 11.—After effects of a barn fire at the John Neufeld farm, 5 miles from Medina, Ohio, at 11 p. m. Fire was fought with Medina community fire apparatus. The barn burned, but corncrib (1), granary (2), chicken house, and another building close by were saved

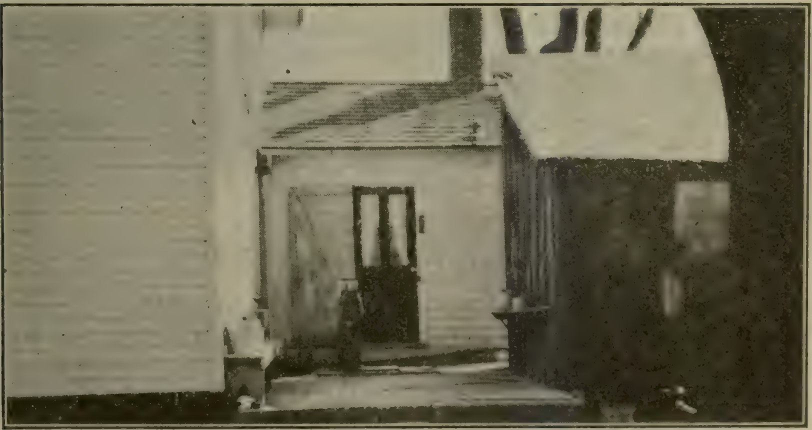

FIGURE 12.—This house caught fire eight times (Fig. 11). but it and adjoining buildings were only slightly damaged. Water to save $6.500 worth of buildings was secured by attaching 30-foot suction hose to cistern pump seen in this picture

Ed Nettleton, who lives nearly 2 miles from Medina, had a large straw-stack fire in 1927. A barn, insured for $8,700, including contents and livestock, and a shed were near. A picture of the barn, taken after the fire, shows one side discolored by smoke. One building was partially afire. A rough dirt road leads to the farm. Water was obtained from a creek 300 feet distant. His son stated that the community fire truck, manned by 12 men, arrived in about 5 minutes and fought the fire, remaining for 7 hours; that the barn, shed, and house were saved; and that the fire department did good work.

The county agricultural agent believed that the community fire truck was performing very efficient service.

The chief of the Medina fire department is one of a number of local deputy State fire wardens, and through his experience he has arrived at certain conclusions. (1) In a rural fire organization the most important thing is discipline. (2) Firemen need training. Fighting farm fires consists of more than pouring on water. Water must be conserved and must be properly applied. Success comes in pumping water through a small tip, usually one-half inch or three-fourths inch, on the hose nozzle; it is not the volume of water pumped through that is important, but the driving of the water through at high pressure. (3) If Medina were to buy another community truck a truck with dual tires would be selected, to give better service on country roads, especially in winter. (4) The Medina community fire truck has paid for itself many times over in the property that has been saved.

On January 1, 1930, the status of the truck was changed, to take advantage of a law passed by the last session of the State legislature, providing that township trustees in Ohio may enter into contracts with any municipality for fire protection for their respective townships.

On July 14, 1930, nine townships had made contracts with the town of Medina. Two of these pay a flat rate of $300 per year for service. The contracts for the others call for payment, in case of fire calls, of $50 for the first hour and $25 for each additional hour or fraction thereof. The apparatus answers calls in and is maintained by the town, which collects all moneys and pays the firemen for their services. After six and one-half months of operation the chief reported that the plan was working satisfactorily.

TOWNSHIP FIRE DEPARTMENTS

Laws have been passed in a number of States making it possible for the people of townships to obtain rural fire service through township taxation. Among the States that make this provision in some form are New Jersey, Indiana, Pennsylvania, Michigan, Minnesota, Ohio, Wisconsin, and Iowa.

In some cases the township provides its own apparatus, and fire-fighting companies may be organized. In other cases the township contracts for services with a town or other unit that possesses apparatus and a fire department. Townships join with towns and voluntary town and country subscribers in buying the community apparatus or in contracting for service. Several townships may join together in action in these capacities. The township apparatus may constitute all the fire apparatus in the township, giving service to farmers and village communities. The township system is considered just and equitable for rural townships.

RURAL FIRE SERVICE FINANCED BY THE RURAL TOWNSHIP OF VERMONTVILLE, MICH.

In 1924 the village of Vermontville, Mich., with a population of 585 people had a volunteer fire company and a small combination hose and chemical apparatus. The company had been accustomed to responding to country fire calls, but as this left the village unprotected it was thought there should be at least one good piece of modern apparatus that would serve the whole township. It was deemed just that the township should finance the apparatus. Farmers compose the majority of the population of the township, which was 1,473, including the inhabitants of the village.

The members of the fire department made a canvass among the country people and found them responsive. A public meeting of farm and village people was held, at which talks were made by representatives of a neighboring community fire company.

FIGURE 13.—The Vermontville Township fire truck at its delivery demonstration at Vermontville, Mich.

The township board of supervisors, the majority of which were farmers, was then approached, and it voted to put the following proposal to the voters of the township in the form of a special ballot, for decision at the spring election:

> Shall the township of Vermontville raise $4,000 in the year 1925 by a general tax spread on all the taxable property to purchase suitable fire-extinguishing apparatus and equipment for the protection of property against fire, as authorized under act No. 28 of the Public Acts of 1923?

Meanwhile the campaign for the purchase of the apparatus was carried on through newspapers and farm organizations by firemen and leading farmers. During this time there was a serious farm-barn fire. The community fire department from a neighboring town responded to call and rendered good service in saving the property.

At the township election the proposition was favorably carried by a vote of 155 yeas to 53 nays.

Apparatus men were called in, and their bids were studied by the township board and the fire department. The apparatus selected was a water pumper with a 150-gallon booster tank, 200 feet of ¾-inch hose, 500 feet of 1½-inch hose, and the usual accessories. A deciding reason for selecting this pump was the claim that it could pump dirty water without suffering damage.

The delivery price of the apparatus and equipment, received in 1925, was $4,100. As $4,000 was the maximum that could be voted by special election, according to the law, $100 was voted from the general fund of the township. In September, 1929, the low-pressure pump on the apparatus was turned in to the apparatus company for a new high-pressure pump, $200 being allowed for the old pump. To complete the $600 transaction the township paid $300 and the fire department $100. (Fig. 13.)

The apparatus is owned by the township. There is a general oral understanding that the village will house and maintain the apparatus and that the fire department will man it, the township to provide needed major equipment and accessories.

The fire company is a volunteer, unpaid organization of 18 men, organized in 1909. The members receive no pay for fire calls, and no charges are made for such calls. The department often receives voluntary donations from those given fire service. One insurance company pays the company $10 for each run to one of its members, regardless of the work performed. Six firemen accompany the truck to farm fires, and about as many more go by automobile.

The fire company is practically self-supporting. Donations made for fire service rendered and receipts from entertainments provide minor necessities and comforts for the firemen. For the two years ended September, 1929, the sum of $220 was spent, mostly by the township, for minor equipment and maintenance of apparatus.

The apparatus is housed in the basement of the village and township hall, built a number of years ago, the upper half of which was financed by the township and the lower half by the village. Various methods are used to maintain interest.

Roads are generally good, nearly all being graveled. Some difficulty is experienced with the water supply, which is drawn from wells, cisterns, stock tanks, streams, and ponds. Farmers were told that if they expected good fire service, water must be available. The construction of cisterns some distance from farm buildings was especially advocated. Ten of these, recently built in farmyards, are constructed of concrete and cement with a manhole at the top; each holds from 200 to 300 barrels of water. Water is pumped into them from wells or stock tanks by gasoline engines or windmills. In difficult situations water is brought to the booster tank and propelled to the fire through the ¾-inch hose.

The fire records show 5 country and 7 Vermontville village calls in 1925; 11 country and 4 village calls in 1926; 7 country and 3 village calls in 1927; 9 country and 4 village calls in 1928; 6 country and 7 village calls up to October 21 in 1929. Of the country calls, all except two from other rural villages, came from farms. Of the farm fires, 27 were building, 8 grass, and 3 straw-stack fires. The causes of the 38 farm fires were listed as: Chimney, 16; grass, 7; lightning, 5; incendiary, 1; unknown, 9.

General commendation was expressed by township and village officials, firemen, and leading farmers as to the township plan of providing fire service to rural communities.

The representative of the insurance company said:

> The township truck saves the insurance company a lot of money. Most farmers are members of our company. We appreciate the work done and gladly vote the payment to the fire department for service to our members. The farmers are very well pleased with the fire service. I do not know of any fire company with a better record. It is all a very good thing.

Said L. R. Curtis, farmer, concerning his house fire caused by chimney sparks in 1926 which was fought by 10 firemen using the booster tank:

> My house, insured for $1,200 suffered $200 damages. The fire department saved my property. I am 2½ miles from town and it didn't seem possible that the truck could get here so quickly. I can't praise the work of the firemen enough.

RURAL FIRE SERVICE FINANCED JOINTLY BY CLAY AND DELAWARE TOWNSHIPS, CARMEL, IND.

The main street of Carmel, Ind., a village of 598 people, is on the dividing line between the townships of Clay and Delaware. Clay township is 6 miles long by 5 miles wide and has a population of 1,268, including part of Carmel. Delaware township is 7 by 5 miles, with a population of 1,396, including part of Carmel.

The village of Carmel bought a small chemical apparatus in 1921. During the campaign to persuade the people of Carmel to vote for the purchase of the truck, the apparatus company gave a public demonstration of its use in the village. Ballots for and against purchase of the truck had been distributed, and many had been returned. During the demonstration a farm fire occurred; some one took the demonstration truck to this fire and saved considerable property. Farmers then became interested in the possibilities of fire service for farmers, and a number requested the town to buy the apparatus. As a final result, 25 of the 80 people who had voted changed their ballots from No to Yes, and the proposition carried.

The town truck responded to both town and country fires. In 1923 a fire occurred on a farm 7 miles from Carmel. The farmer called the fire company of another and larger town, but it is claimed that permission for the truck to go was refused. The Carmel truck was then called; it responded and saved an 8,000-dollar farm building.

Farmers then began to think that they should have unquestioned fire service. Petitions were circulated to buy apparatus by voluntary contributions of farmers. This was not very successful, as many farmers thought the equitable way would be for the townships to buy the apparatus.

Leading farmers, including officials of the farmers' mutual insurance association, began a campaign to have the two townships buy apparatus. As the village of Carmel would house and be served by the truck the matter was to be decided by the governing boards of the two townships and the village. A joint meeting of the three governing boards was called to consider the matter, and farmers and insurance officials advocated the proposition. The principal talk made in favor of buying apparatus was by the farmer secretary of the farmers' mutual insurance association who had lost his home (valued at $8,000) the previous week, partly because the town apparatus was too small. It saved the other buildings. Representatives of apparatus companies attended this meeting. It was decided to buy the apparatus, and the proposition was favorably acted upon at separate meetings of the three boards.

The apparatus, bought in October, 1927, was made according to specifications. It is a chemical truck equipped with six 35-gallon chemical tanks, with three sets of 150-foot hose, each set of hose on a battery of two tanks. Thus a continuous stream may be had. The chassis was bought separately and sent to the apparatus factory to be mounted.

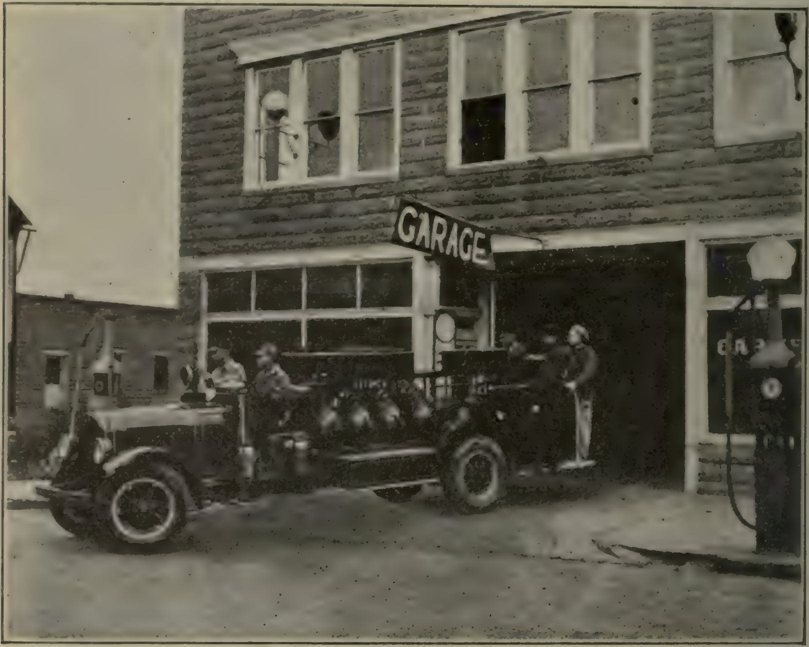

FIGURE. 14—Fire apparatus bought by Clay and Delaware Townships at the Carmel, Ind., garage where it is kept

The truck cost $5,250 equipped. To finance the purchase of apparatus, an assessment of taxable property was made in each township of 10 cents on the $100. This provided $2,860 for Clay Township and $3,010 for Delaware Township. In the latter township, across a river and farthest from town and difficult of access for a truck from Carmel, is a village of 142 population. Delaware Township officials decided to withhold $1,250 of its money for separate apparatus for this village. To make up the balance needed to pay for the townships' truck, the village of Carmel added $630. When a Carmel taxpayer objected to this with the phrase "double tax" the answer given was "double protection," as there would be two trucks in the town.

The truck is owned by the two townships and bears the inscription, "Clay and Delaware Townships." One of the considerations impelling the village of Carmel to vote $650 for the apparatus was an agreement by the two townships to maintain the truck. The village pays the maintenance expenses direct and charges them to the two townships, in proportion to the number of fire runs made in each township.

During the four years the old truck was in use (up to December 31, 1928) the cost of maintaining it was $321. Donations for specific fire service and by the insurance company for general service in farm fires amounted to $446. Maintenance expenses of the old truck for 1927 and 1928 and of the new truck from October 7, 1927, to December 31, 1928, was $773. The assessed valuation for 1928 of Clay and Delaware Townships, respectively, were $2,990,250 and $3,113,900, a little larger than in 1927. That of Carmel village, separate, was $631,270.

The apparatus is housed near the center of the village in a concrete garage, 50 by 132 feet, operated by the fire chief. (Fig. 14.) Eight of the twenty-six stalls are rented to the townships, through the village, for an annual rental fee of $240. Six of the garage men are members of the fire company and can operate the truck. A lot has been purchased for the location of a new fire house.

Nearly all of the farmers have telephones. In case of a fire the telephone central operator, by special ring, calls the garage where there are several firemen day and night. They man the truck and go to the fire, followed by other firemen in automobiles. There is a large siren on the truck.

The volunteer fire company, organized in 1922, consists of 10 men, including the chief. The only pay they receive is $1 an hour each for their time on fire runs. Liability insurance is carried on firemen for fire service.

From June 1, 1923, to October 7, 1927, the small village truck responded to 56 fire calls, 30 of which came from the country. Of the 56 fires, 28 were houses, 8 barns, 6 motor vehicles, and 14 were small outbuildings, grass, etc. The total loss reported was a little over $42,000. Property saved was estimated at $130,000.

From January 1, 1927, to December 31, 1928, the two town and township trucks had 25 runs, evenly divided as to townships, 1 automobile fire occurring on the dividing line. Seventeen of the fires were in the country. According to the fire-record book, the value of the buildings on fire was $96,500, the fire loss was $11,535 and value of property saved was $84,965. Three of the fires were caused by lightning. It is claimed that in no case has an adjacent building been lost.

Table 1 shows the value of buildings, building fire losses, and distances of buildings from the village, for each fire fought in the country and village by the townships' truck during 1928.

TABLE 1.—*County and village fire statistics for each fire served by the townships' truck in 1928*

Place of fire	Value of building	Fire loss	Distance from village
	Dollars	*Dollars*	*Miles*
Farm	1,000	5	3
	4,000	5	1
	4,000	4,000	6½
	3,500	2,010	2
	3,600	200	4½
	2,000	200	3
	2,000	10	5½
	4,000	5	6
Total	24,100	6,435	
Carmel village	3,500	250	
	2,000	250	
	3,000	300	
	2,000	20	
Total	10,500	820	

In addition there were 7 grass and automobile fires and false alarms. The $4,000 total loss was a house fire at 9 p. m., 6½ miles from town, caused by chimney sparks. It is reported that the discovery of the fire was delayed and that there was not sufficient water available for the recharging of the chemical tanks. Valuable outbuildings were saved.

The fire company continually advocates fire prevention and the number of fires seems to be decreasing, the number during the year 1929 having been the smallest.

Satisfaction was expressed by farmers, insurance officials, town and township officials, and firemen with the township's truck and the method of financing it.

A farmer, secretary of the farmers' mutual insurance association of Hamilton County and president of the State federation of mutual fire-insurance companies said:

> If every township had a truck like ours every rural district would be well protected. This truck can fight fires. I lost an 8,000-dollar house by fire just before this truck was purchased. The old truck came, but it was too small, although it saved some outbuildings. If we had had this truck we would have saved all. Our State federation proposes to arrange meetings over the State in order to persuade all rural districts to get apparatus.

Mrs. Kinzer, on whose farm a fire occurred, said:

> Returning from town I discovered the windmill on fire. Several other buildings were blazing on the sides. I started to remove the furniture from the house, but the truck arrived before I had taken out more than a few chairs. Only the windmill burned. The damage was only $300. The fire company came quickly and did fine work.

In estimating the value of the truck, much emphasis is laid by farmers and insurance officials on a report issued by the Farmers' Mutual Insurance Association of Hamilton County, concerning farm fires in the county in 1928. This report shows that the association had on its books insurance in the county amounting to $10,798,292, on December 31, 1928 (excluding $165,685 of reinsurance and short-term insurance which is not subdivided as to townships in the report). Of this total amount of insurance, $1,970,525 was in Clay and Delaware Townships and $8,827,767 was in the other seven townships. Thus a little over 18 per cent of the insurance was in the two townships. The total losses paid for the year in the county were $29,368.38 of which $27,091.19 were fire losses and $2,277.19 were lightning losses. The total losses in Clay and Delaware townships were $427.99, or less than 1½ per cent of the total.

COUNTY FIRE DEPARTMENTS

Taxation is the financial method employed by county units. In one type the county operates its own apparatus and fire-fighting crew to serve rural people and authorizes the formation, according to law, of local rural fire districts, which finance their own apparatus, departments, and fire houses by local taxation, all under the direction of a county fire official as one grand county fire department.

From the standpoint of magnitude of service, Los Angeles County, Calif., is the outstanding example. In addition to apparatus and fire fighters for rural use, the county department includes 35 departments in 28 legal fire districts with locally financed departments, apparatus, and fire houses, involving a rural population in unincorporated territory of 310,345 people. The county department has 150 paid officers and men, most of them uniformed. All of this is exclusive of the county mountain and forestry fire service. It is said to be the third largest fire-fighting organization on the Pacific coast.

Another county type finances the formation of separate rural fire departments and their apparatus and partially finances their annual maintenace. Wicomico County, Md., is an example.

Another type finances rural apparatus and contracts for rural service from one or more town fire departments. Jackson County, Mich., and Napa County, Calif., appropriated $9,500 and $4,500, respectively, in 1929 for rural-fire service and contracted with their county-seat towns of similar names for rural service. Davis and Utah Counties in Utah each contract with several towns. Some counties finance county fire departments and apparatus and station them in strategic rural points within the county.

Fire departments financed by counties represent financial equalization and have a basis of reasoned validity and often of special enabling acts.

A COUNTY FINANCES A FIRE DEPARTMENT WITH TWO UNITS FOR RURAL SERVICE, SALT LAKE COUNTY, UTAH

The county fire department was organized in 1921, starting with a small appropriation, to give service to rural people. The county farm bureau was instrumental in persuading the county to enter into rural fire-protective activities as many farmers had been requesting such service. The Salt Lake City fire department does not respond to rural fire calls, except with permission of the mayor or committee of public safety.

The mechanical shops of the county road and bridge department, where 75 men are employed, are located at Murray, population 4,584, about 9 miles from Salt Lake City. The county considered that this would be a good place for headquarters for a county fire department since it was in rural territory near the center of the county.

apparatus could be housed at the shops, and shopmen of mechanical ability there could be invited into the service.

The county has bought the following apparatus: (1) One new chemically equipped truck, capacity 100 gallons per minute, with two hand extinguishers. Designated as the chief's car, it answers calls and makes inspection tours. It cost $4,500. (2) A water pumper, capacity 750 gallons, with 1,500 feet of 2½-inch hose, 50 gallons of chemical, and 2 hand extinguishers. It cost $16,500 fully equipped. (3) A combination pumper, capacity 600 gallons per minute, with water tank carrying 500 gallons, equipped with a foam generator, 2 hand extinguishers, 100 pounds of foam powder, 250 feet of chemical hose, and 500 feet of 2½-inch hose. It cost $10,000. (4) A water pumper, capacity 500 gallons per minute, with 1,000 feet of 2½-inch hose, a 40-gallon chemical tank and 2 hand extinguishers. This was bought in 1921 and is fairly modern, equipment having been added gradually. It cost $12,000.

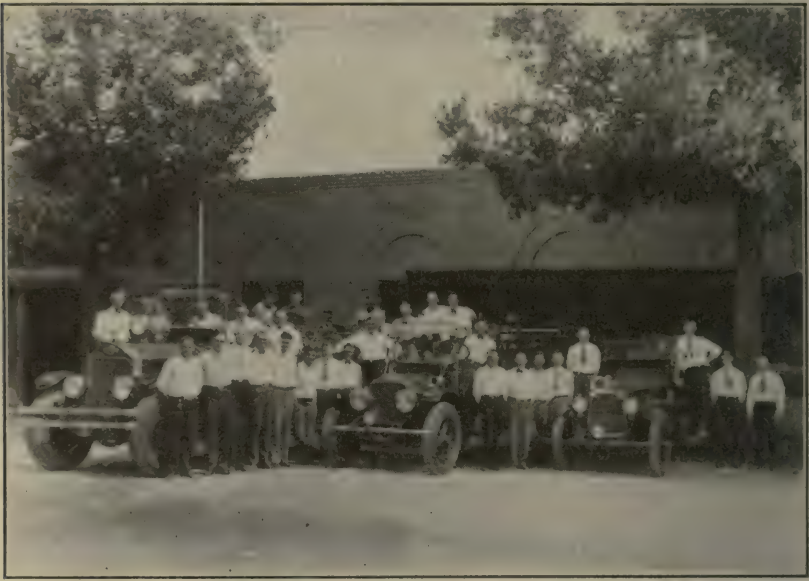

FIGURE 15.—The three pieces of rural fire apparatus purchased by Salt Lake County, Utah, together with county department unit No. 1, in front of the county fire station, No. 1, at Murray. The fourth county truck is stationed at Magna

Three rural trucks are stationed at Murray (fig. 15) and a fourth one at Magna, an unincorporated town, with a population of 1,515, about 12 miles distant. The town of Murray has three pieces of town apparatus. The Magna apparatus serves a territory with a radius of 10 miles. The rest of the county rural territory is served by the Murray apparatus which covers a district extending 6 miles north, 8 miles east, 15 miles south, and 15 miles west. There are several other town fire departments in the county which the county department must assist on call. The county fire department and the Murray town fire departments have reciprocal relationships, but Murray does not assist the county except on call.

County department unit No. 1 at Murray is a volunteer unit consisting of 30 men, of whom 12, including the chief, are county shop employees, the others being employed about town. The chief of the department receives $160 per month for shop and fire duties and the assistant chief receives 75 cents an hour, mostly for shop service. The captain of unit No. 2 at Magna, which is also a volunteer unit, receives $50 a month. Each of the men receives $1.50 the first hour and $1 each succeeding hour from the county while responding to fire calls. In addition, each man receives a lump sum of $2 per month from the county for fire service. The majority have been firemen seven or eight years. At Murray, from 12 to 15 men respond to rural fire calls, 3 on the chief's car and the others on other apparatus.

The Murray apparatus is housed in a room, 40 by 30 feet, of the county shop building, a 1-story brick structure. Plans are being made for buying another building for the use of the fire department. The Magna apparatus is housed in a building, 30 by 30 feet, built for fire-department purposes by the county.

The water supply in the county is not entirely adequate, especially in winter. In some places only water from open ditches is available; in some villages and farm districts there are pipe lines with hydrants. Diversified farming is carried on in an irrigation district, and when irrigation ditches are dry not many cisterns are available. Roads are generally good; the main arteries are paved highways, and the rest are of gravel.

Expenses incident to the department in 1929 were provided for according to the following budget:

Maintenance of fire trucks, repairs, labor, and material	$3,500
New equipment, balance on truck	8,240
Firemen's compensation, 50 men at $2 a month, 50 men answering calls	7,200
Sundries, unclassified; rent, $480; light, $15; water, $24; equipment, $1,000; repairs to equipment, $500; fuel, $181; total	2,200
Building maintenance, repairs, etc	500
Total	21,640

It will be noted that $8,240, to be spent in 1929, was to apply on a truck purchased.

From June 1, 1929, to August 22, 1929, the unit at Murray responded to 32 fire calls. One-half of these were for brush and grass fires, and one-fourth of the remainder were for chicken-house and brooder fires. Two were for residence fires. The total fire damage ranged from $200 to $300. During the year July 1, 1928, to June 30, 1929, this unit responded to 123 fires, mostly on farms. The classification of fires was similar to that of the shorter period.

The county fire department is credited with doing effective service for rural people. A member of the board of county commissioners said:

> The department gives splendid service. We have received many letters from people who had fires expressing a feeling of gratitude for the good work done by the department. General sentiment and newspaper reports are favorable. The few complaints have been of a minor nature, largely in regard to the location of the apparatus.

The home of Mrs. Hague was threatened by a brush fire, in which from 2 to 3 acres were burned, including 200 big trees. Mrs. Wallace, her sister, stated:

After a boy had tried to put out the fire, we called the department by telephone. It came the 4 miles very promptly and did very good work. Brush fires sweep rapidly in the wind. It was necessary to pump water from a ditch for two or three hours. If the fire department hadn't come the whole country around here, including several houses, would surely have burned.

A COUNTY FINANCES RURAL FIRE SERVICE THROUGH COOPERATION WITH LOGAN, CACHE COUNTY, UTAH

Logan City and Cache County Fire Department has been in existence since January 1, 1924. Previous to that time it was the Logan Fire Department.

Cache County has an area of 1,164 square miles, a population of 26,992, the population outside of Logan being 17,553.

The Logan Fire Department was not permitted to leave the town except with the permission of the mayor; it was said this limitation was due to the opposition of the insurance underwriters. A few villages of the county had small fire departments for their own service. The Logan Fire Department had many calls from farms but had to refuse assistance. Committees of farmers petitioned the aid of the various farm bureaus, whose officers studied the matter, and the majority of them voted in favor of establishing a county fire department. Farmers appeared before the county commissioners and petitioned for a county fire department.

In the latter part of 1923 the county of Cache and the city of Logan entered into an agreement for one year, effective January 1, 1924, the principal provisions of which are as follows:

> (1) The county to purchase 1 triple-combination hose, chemical, and pump truck, with complete equipment, including 2,000 feet of double jacket hose and 2 nozzles, to be under the supervision of the city fire chief. (2) The city to house and maintain the apparatus, in consideration thereof the county to pay the city $1,500 for the remodeling of the city fire house. (3) The city to employ as its fire department, 7 men at its own expense and 2 additional men at an expense of $3,000, paid by the county, to be under the supervision of the city fire chief. (4) The apparatus to be used in the service of the city, but the county to have prior right to the service of the triple-combination truck. (5) The city fire department is to use all due diligence in extinguishing fires outside of the city, using as much of its apparatus as may be necessary. (6) All accidents or breakages to any apparatus happening outside of city, while answering calls, to be charged to the county; all maintenance charges to be paid for by the city; all gas and oil charges up to $120 per year to be paid by the city, but all in excess of $120 per year to be paid by the county. (7) The county to pay the insurance premiums of 2 firemen, provided for under the workmen's compensation law, and to be relieved of all other accident liability to firemen.

The city also has a similar triple-combination truck, one other combination truck, and a chief's car with hose attached. Four firemen accompany the apparatus to the country if there is no fire in the city; otherwise three go.

The total cost of the county apparatus and equipment was $13,897.50, payable in annual installments. The 1924 county budget for the fire department was $3,000, exclusive of the $3,378.75 installment on the apparatus. The 1925, 1926, and 1927 budgets were each about $3,200, and the 1928 budget was $4,435. The 1929 budget included fire prevention, $125; salaries, $3,600; extra men, $820; equipment and repairs, $900; total, $5,445. This budget covered department reorganization.

After one year the original contract was renewed in similar form for five years. On January 1, 1930, the contract was renewed for one year with a county budget of $4,630.

This is an irrigation district and water from the ditches is generally available. Cisterns, ponds, and creeks are also used. One-fourth of the roads are paved, and most of the others are graveled. Farmers' lanes are good except in winter.

In 1928, the department took first place in the State, in the contest of the National Fire Waste Council for fire prevention and protection. An active county fire-prevention campaign is carried on, consisting of the distribution of pamphlets to all schools, fire talks and drills in schools and public places, and the awarding of a flag to the school with the best fire drills and home fire-inspection reports.

Up to November 30, 1929, the department had responded to 151 alarms outside of Logan. The loss from the fires involved was approximately $87,870; the valuation of the property endangered was approximately $306,600.

To a number of inquiries concerning the success of the system the responses were uniformly favorable.

The county agent stated:

> The farmers wanted the arrangement. I think it is doing very creditable work and is a satisfactory system for this county. Farmers who had fires have commented to me very favorably. I have heard many farmers praise it and no complaints.

The fire chief said:

> The protection offered is not only a big thing for the farmer but it also helps the small towns. I believe that the county fire department has saved the citizens, outside of Logan, $218,730 of property in the six years of its existence.

SUMMARY OF IMPORTANT POINTS

Practice has demonstrated that certain methods of procedure are valuable in the organization of rural fire protection.

Temporary organization.—A temporary organization gives weight to the enterprise. Important groups and organizations in the community are included, such as the farm bureau and the grange.

Laws.—State and local laws are studied to determine under what law, regulation, or method, it is best to proceed. The common nonprofit voluntary association law is employed if there is no special law.

Selecting the type.—The examples of successful rural departments presented in this bulletin disclose various types. A type to fit local conditions is decided upon.

Preliminary survey.—Before a campaign is started a survey of the district is made. This includes the area, dimensions, and population of the territory to be included; roads; the terrain and natural barriers, to see if any contemplated part should be excluded; the water supply available or possible; present and future financial resources; and consideration of permanency of the district.

Campaign.—After the type is determined comes a campaign to initiate, follow up, and conclude the enterprise. This involves such things as appointment of committees, public meetings, speeches, securing the cooperation of leading men and organizations, persuasion of the electorate and legislative bodies, solicitation of subscriptions, issuance of fee statements or circulation of stock certificates, etc.

People who have had experience in conducting other campaigns for rural fire departments are called in for advice and assistance. Salesmen of standard apparatus may be invited to assist.

Propaganda.—Publicity is employed to influence favorably the progress and conclusion of the campaign. Local newspapers are used, and the merits of the proposition are clearly set forth. Speeches are made, bills are posted, and circulars are distributed.

The drive for funds.—The drive for funds comes after public opinion has been awakened. The drive is well organized and systematic. Names of the people in the district are secured from tax and telephone lists and are assigned to solicitors, who are leaders in the community, preferably with soliciting experience. The solicitors know something of fire departments and apparatus and can explain the service expected and answer possible objections. Paid solicitors are sometimes the most effective. A fixed sum is generally solicited, but not always. Free fire service is usually promised during the life of the apparatus or a fixed service fee is agreed upon. Subscription blanks are more effective than simple promises. The publication in newspapers of lists of subscriptions is helpful.

Purchase of apparatus.—Great care is exercised in purchase of apparatus. Apparatus from high-grade standard apparatus companies is considered. Some companies specialize in apparatus that is especially adapted to country conditions. Good rural apparatus, suitable for country roads, building height, and water conditions, is available at prices suited to rural financial conditions. Apparatus salesmen who come into rural communities uninvited and solicit subscriptions by high-pressure methods before the way has been prepared, and then quickly depart, are avoided. Good apparatus salesmen have been found valuable in assisting in the campaign.

One valuable practice is to send a competent committee to some other community where apparatus similar to that needed has been in successful operation.[4]

Permanent organization.—Permanent organization comes at the conclusion of the campaign and includes all the subscribers, if it is a voluntary enterprise. Organization tends toward permanency, gives members continued interest, and provides a body which may own the apparatus and whose officers may represent it in contracting for service from town fire department, if need be, or in making regulations regarding the use of the apparatus.

Constitution.—The organization adopts a constitution and by-laws. These provide for regular annual meetings at least, for specially called meetings, and for committees and officials who may operate between meetings.

Contracts, agreements, and regulations.—These relate to the use of the apparatus, especially contracts with towns or other bodies for service. They are put in writing in detail, subject to future change by agreement.

Ownership.—Ownership of apparatus is not to be left in doubt, as complications may arise in the future. A written understanding is needed. Some of the best farmers' associations reserve ownership of apparatus and contract with towns or fire departments for service. In town and country enterprises ownership may be vested in the community fire association, or in the town or fire department, with a written agreement as to its use for farm fires.

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[4] For technical information concerning apparatus the reader is referred to the report, Rural Fire Departments, Equipment and Organization, prepared by the farm fire protection committee of the National Fire Protection Association, 60 Battery March Street, Boston, Mass.

Fire-fighting company.—In a fire department the organization is considered as important as the equipment provided. Responsible officers and trained men are needed. Discipline, pride, and interest in the work, and a good morale are aims of all good fire departments. The personnel receives careful consideration. Local men, energetic and of good physique and moral character, and mechanically inclined, are preferred. Officials are natural leaders and disciplinarians, must know their job well, and merit the respect of their men. Competent officials take good untrained men and make an effective fire-fighting force in a short time, through practice at fires, drills, fire schools, and demonstrations.[5]

Maintenance of interest.—Interest of force and of subscribers is maintained through other community endeavors and through social events both small and large. County, regional, and State fire-department associations are formed, and the meetings are attended by local delegates.

Men and apparatus are not the whole of a fire department. The following factors help to make a department complete and efficient:

Fire house.—A separate building makes better care of the apparatus possible, lends permanency to the organization, and strengthens the morale of firemen. Separate rooms for a meeting place, reading, games, and a lounging place are found in the best buildings. Some have dormitory space for firemen. Some good rural departments are found housed in rented parts of garages and other buildings. Buildings are near the center of the district, and are easily accessible.

Water.—Water is generally available from some source in rural districts. Cisterns, wells, tanks, ditches, streams, ponds, and lakes are used. Where water is insufficient, permanent dams are built; cisterns are constructed separate from buildings; windmills are erected; and neighboring farmers bring water to the fire in milk cans or other receptacles, or they form bucket brigades.

Roads.—Rural fire departments are an inducement for the proper authorities to build good roads. Farmers are encouraged to have good entrances from highways and, under certain conditions, solid foundations for placement of apparatus in their yards.

Telephones.—Farmers in fire districts need telephones to call the departments; many farmers have them. Special arrangements are made with the telephone company to relay farm fire calls, night or day, to the fire house or the homes of firemen.

Alarms.—Special alarm systems to arouse firemen and others are provided at fire houses. The fire apparatus is provided with a siren.

Final surveys.—Fire companies or associations make complete surveys of their districts. The items include the condition of roads, bridges, and farmers' lanes; the location of creeks, lakes, ponds, and rivers; information concerning the number and position of buildings, and the best and most direct road to them, size of water outlets on tanks and reservoirs, location of gates, distance from fire headquarters, and water supply actual and potential.

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[5] For technical information on fire-department organization see footnote 4.

Maps.—Wall maps are made and hung in the fire house, showing the general information indicated by the survey. When a fire call comes a glance at the map reveals necessary information.

Card files.—Detailed information secured concerning each set of buildings is placed on cards. When a fire call comes from a certain building the card may be carried along by the fire chief or firemen.

Fire drills.—Fire drills and demonstrations under varying conditions are held frequently by the company. These help to train the men, sustain their interest and morale, and keep up the interest of the people in the department.

Fire records.—Records of fires fought are kept in books, which can be bought for the purpose. This information includes, for each fire, name and address of owner and of tenant, if there is one; time of call; distance to fire; time occupied at fire and in going and coming; buildings involved; nature of fire; cause; number of men sent; apparatus used; value of each building on fire and of its contents; financial loss on each building; total loss; and the value of property saved.

Inspections.—To insure that apparatus is in shape for any emergency, daily inspections and frequent tests of vital parts are made by competent men.

Training schools.—That firemen may know the various methods of fire fighting under varying conditions and how to operate apparatus, training schools are held. Experts may be called in as teachers. Several colleges now include fire schools in their curriculums.

Relief associations.—Relief associations are organized by some departments on the voluntary-contribution plan for the financial relief of member firemen injured on duty, or for their families in cases of death.

Fire prevention campaigns.—Fire-prevention campaigns are conducted by fire officials throughout the year in schools, churches, and other organizations, and through the press. Moving-picture films have been made and are sometimes used. Such campaigns tend to make property owners more vigilant as to fires, to remove fire hazards, and to reduce the number of fires.

U. S. GOVERNMENT PRINTING OFFICE: 1931

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - Price 10 cents

U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1668

The RED HARVESTER ANT

AND HOW TO SUBDUE IT

1862 1889

THE RED HARVESTER ANT causes both loss and annoyance in many parts of the Southwest.

These large ants rob the farmer of a considerable quantity of seeds, which they store away for food, and cause even more loss by denuding of vegetation large areas around the nest. They also both bite and sting on slight provocation.

This bulletin describes the various forms and manner of life of these ants, and the structure of their underground nests. It tells some of the best methods for getting rid of their colonies and shows the futility of some of the measures that are frequently recommended. It also emphasizes the necessity of very thorough and continuous treatment in order to attain success.

Washington, D. C. **Issued August, 1931**

THE RED HARVESTER ANT AND HOW TO SUBDUE IT

By V. L. Wildermuth, *Senior Entomologist*, and E. G. Davis, *Assistant Entomologist, Division of Cereal and Forage Insects, Bureau of Entomology*

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WHERE THE ANTS ARE FOUND

THE RED HARVESTER ANT, *Pogonomyrmex barbatus* F. Smith,[1] is an insect that causes considerable losses in cultivated fields and orchards in the Southwestern States. The circular, bare areas (title illustration and fig. 5), often as much as 25 or even 35 feet in diameter, cleared of vegetation by colonies of these ants, stand out prominently in alfalfa or grain fields in this part of the country. Not only is this ant destructive to cultivated crops, but it is also a great annoyance around dooryards and is especially troublesome when in city lawns. In such locations the ant is a nuisance not only because of its harvesting activities, but also because it has the unpleasant habit of inflicting painful stings, as almost all residents of a district where this ant occurs can testify.

Because of its peculiar habits this ant is extremely hard to control. As the ants work to a great depth beneath the surface of the ground, the expense of control is rendered rather high, and at times, as discussed later in this bulletin, very uncertain.

It is found at the lower altitudes in Texas, New Mexico, Arizona, and California as well as in old Mexico. The colonies are naturally much more numerous in cultivated areas than on the surrounding desert where food would be scarce, and are much more numerous in some localities than in others. One field may be literally dotted with colonies, and an adjoining field may contain only an occasional nest. An inspection of eight acres at Tempe, Ariz., revealed the presence of 265 colonies, each colony surrounded by a cleared area five feet or more in diameter. This is an average of over 33 colonies per acre.

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[1] There are many varieties of this species, but this popular discussion applies in a general way to all of them. This ant may be distinguished from the mound-building prairie ant, *Pogonomyrmex occidentalis* Cresson, by the absence of a mound at the main opening in the center of the circular cleared area known as the "colony" or "hill." The mound-building prairie ant occurs in the higher altitudes and colder districts throughout approximately the same territory over which the red harvester ant is distributed. The habits of the colony, their methods of feeding, and the means of control are practically the same for both species. The mound-building ant apparently developed this habit of constructing a mound at the entrance of its nest to obtain a greater benefit from the rays of the sun during the cooler periods of its active season. This mound could also be considered as a sun parlor for the development of the growing ants.

LOSSES CAUSED BY THE ANTS

The greatest loss caused by these ants is the result of land wasted in their barren areas and runways. A 20-acre field will often have the equivalent of 100 average-size colonies with cleared circles 12 feet in diameter. Such a field would contain a little more than one-quarter of an acre of wasted land. The loss in dollars and cents on this quarter acre would depend on the kind of crop grown. In a field producing with four cuttings five tons of alfalfa hay per acre the loss, at $10 a ton, would be $12.50. On the other hand, a 20-acre field in short-staple cotton yielding three-fourths of a bale, or 375 pounds, per acre and selling at 18 cents per pound would show a loss of $16.87 per year because of the lost quarter acre.

When the colonies are located in a field that is being planted to citrus, dates, grapes, or other high-priced fruit products, the ants often destroy many trees or shrubs, and the loss thus occasioned sometimes is many dollars per acre. Under these conditions the owner can afford to spend considerable money and time in controlling this insect.

The ants also cause a direct loss to seed crops by collecting seeds for storage. In the case of small seeds, such as alfalfa, this loss may be considerable. If the seed is selling at 17 cents a pound, 100 colonies on 20 acres of alfalfa land consuming 1 pound of seed per colony, which would be a fair average, would cause a loss of $17. The loss which the ants occasion in the fields of other cereal crops depends upon the size of the seed being grown. In the case of the larger kinds of seeds the loss is not so great because the ants prefer the smaller kinds.

A loss not so easily measured is that caused by the ants in collecting freshly sown seed. This loss is especially heavy in newly seeded alfalfa fields where the gathering of seeds results in a thin stand for several seasons in the vicinity of the colonies. Where the larger grains are sown, the loss would not be so great. Nests have been found, however, whose chambers contained considerable quantities of oats collected from recently planted fields.

ANNOYANCE TO PERSONS AND ANIMALS

Much annoyance is caused by colonies located close to dwellings, public buildings, dooryards, and corrals. The presence of the ants about the yards and grounds of dwellings makes the use of these places for pleasure or recreation almost impossible. The ants, running promiscuously about these places, invariably get on people, and if molested may bite or sting or both. Because of this pugnacious habit small children can not be left alone out of doors where the ants are present. Livestock may also be greatly annoyed by these pests. Dairy cows may exhibit numerous swellings, especially on the udder, as the result of stings. Such attacks often reduce milk production.

DESCRIPTION OF THE STAGES

In its life cycle the ant passes through four stages (fig. 1), the egg, the larva, the pupa, and the adult or full-grown ant.

THE EGG

The eggs, which are laid by the queen in the chambers of the colony, are about half the size of a pinhead. They are longer than wide, are shaped like capsules, and are iridescent milky white. They are usually found clustered together, but because of their small size and the fact that they are present only in the underground chambers of the colony, they are very seldom seen.

THE LARVA

The larvae or grubs (fig. 1, D), which hatch from the eggs, also remain in the chambers of the colony. They are cream colored and are shaped like crooknecked squashes, the smaller crooked portion ending in a very small head. The length of the full-grown larva, not including the portion turned back, is about one-fourth of an inch.

THE PUPA

The pupae (fig. 1, E) are about the same size as the adults but are a pale cream color and have the legs and feelers or antennae folded on the underside.

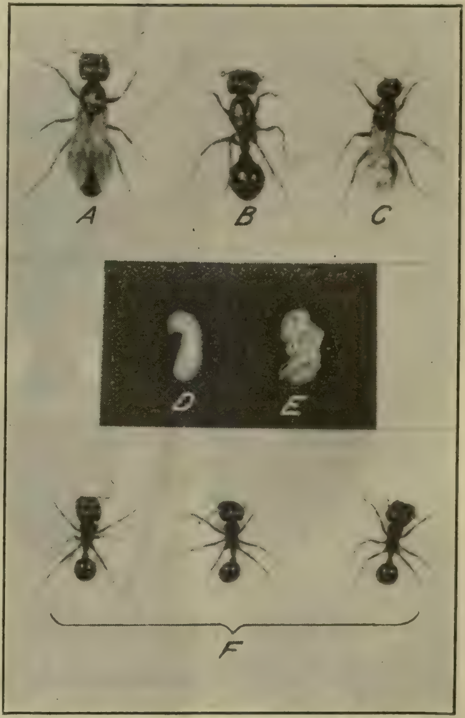

FIGURE 1.—Forms and stages of the red harvester ant: A, Winged female; B, queen; C, male; D, larva or grub; E, pupa; F, workers. All are about one-half larger than natural size

These three immature stages remain hidden in the chambers of the nest and are seldom seen except when the ants, as sometimes, are observed carrying the larvae or pupae to a new location. The pupae are then often mistaken for the eggs.

THE ADULT

There are four different forms of the adult ant; these are winged females (fig. 1, A, and fig. 2), queens (fig. 1, B), males (fig. 1, C), and workers (sterile females) (fig. 1, F, and fig. 3). The workers are the reddish-brown ants seen in large numbers hurrying to and from the colony in search of food. They range in length from a fourth to a half inch. These ants are well known for their pugnacious habits and painful stings. The winged males and females are the sexually mature individuals which emerge from the colony during swarming time to mate and establish new colonies. The females are larger than either the workers or males and may be distinguished from the latter by their slightly darker, more robust bodies, and larger heads. The males do not possess stings. The queen is merely a mated female that has discarded her wings and has established a colony.

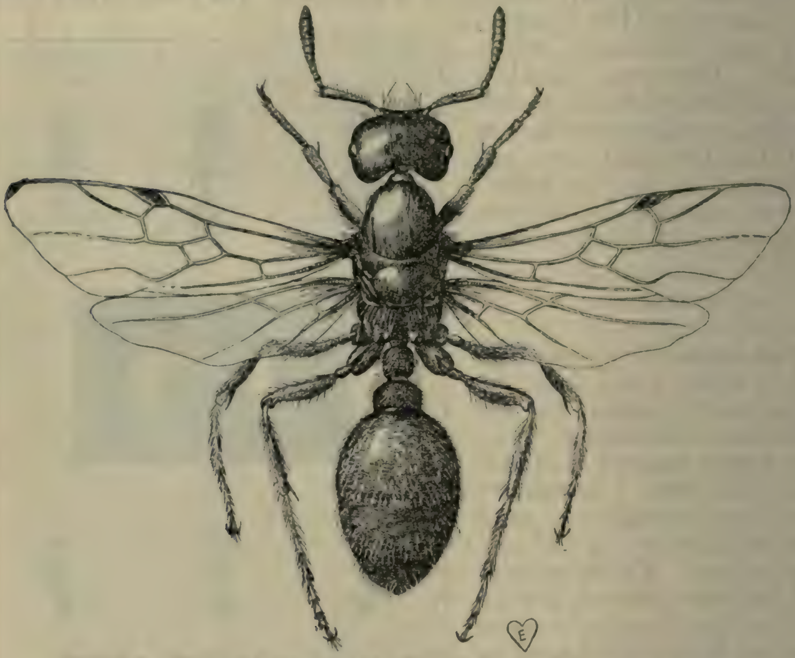

FIGURE 2.—The red harvester ant: Winged female, 5 times natural size

HABITS OF THE ANTS

The red harvester ants are social insects which live together as a colony. The colony consists of one queen and innumerable workers, together with eggs, larvae, and pupae. The winged males and females appear only at certain times of the year. Like other ants, the workers are very strong, being able to carry objects several times their own size. The workers are quite vicious when molested, but go busily about their tasks when left undisturbed. It is only when something interferes with their activities that they become hostile. The colony stubbornly resists interference, and the pugnacious habits of its members have caused them to be known as among the most ferocious of all American ants. When molested, they not only turn to give battle but actually run about in search of the intruder. When once they have set their powerful jaws in an object there is no way to remove them without tearing the head from the rest of the body, and even then the jaws may remain locked.

A possibly more effective weapon for defense is the sting. This needlelike appendage at the end of the abdomen can be thrust into the enemy and a poison injected. This poison is irritating to animals and causes considerable pain and swelling to human beings, especially to those of a susceptible nature.

STRUCTURE OF AN ANT NEST

The nests of the red harvester ant are readily recognized by the well defined, flat, barren, circular area on the surface of the ground, from which the vegetation has been removed. An examination of approximately 300 colonies in an 80-acre field at Tempe, Ariz., showed the average diameter of the cleared area, or disk, to be 12 feet, though they range from 3 to 35 feet in diameter.

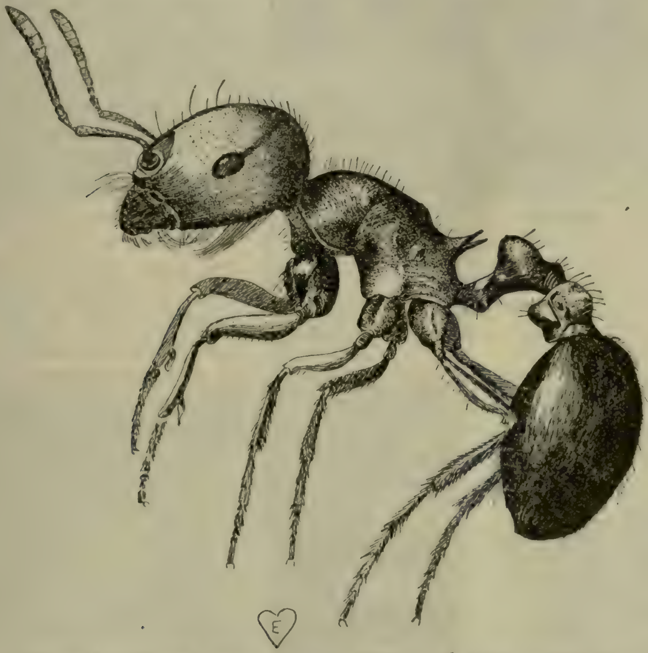

Figure 3.—The red harvester ant : Worker, 12 times natural size

The entrance into the nest is an opening which is usually located at about the center of the disk. Frequently, especially when the colony has been disturbed by cultivation, more than one entrance hole is found. This entrance, which joins the network of tunnels and chambers underground, is normally from one-fourth to one-half inch in diameter.

Radiating from the cleared area on the surface are usually one or more pathways leading into the surrounding vegetation. These pathways are from 1 to 4 inches in width and range in length up to 200 feet; where they adjoin the nest they are as barren as the cleared disk, but gradually become less distinct toward the farther end, where they eventually disappear among the vegetation. The paths serve to make travel easier and faster between the nest and the area that is being harvested by the workers.

The nest (figs. 4 and 7) is a series of subterranean tunnels and chambers. The tunnels are pathways, about one-fourth of an inch in diameter, leading in and out of the nest and from one chamber to another. They extend downward at different locations (fig. 7), each with its separate series of chambers. The chambers are rooms or shelves that are scattered throughout the tunneled area. They are flat-bottomed, but each has a dome-shaped ceiling. They range in size from those that are one-fourth inch wide and one-half inch long to those that are 8 to 10 inches wide and a foot long, the larger ones usually being lower down. Stores may be found in any of the rooms, but those near the surface of the ground are used at times as nurseries in which to rear the young. The larger compartments in the lower half of the nest serve as hibernating quarters for most of the ants during the winter.

Several nests were excavated during the study of this ant. A nest of average size, or one having a cleared area 12 feet in diameter, was excavated at Tempe, Ariz., by the junior writer in 1929. This nest contained 436 chambers, over half of which were within a foot of the surface of the ground. The tunneled area was 7 feet in diameter and extended to a depth of 15 feet, which was 1 foot above the water table. A total of 12,358 ants were counted.

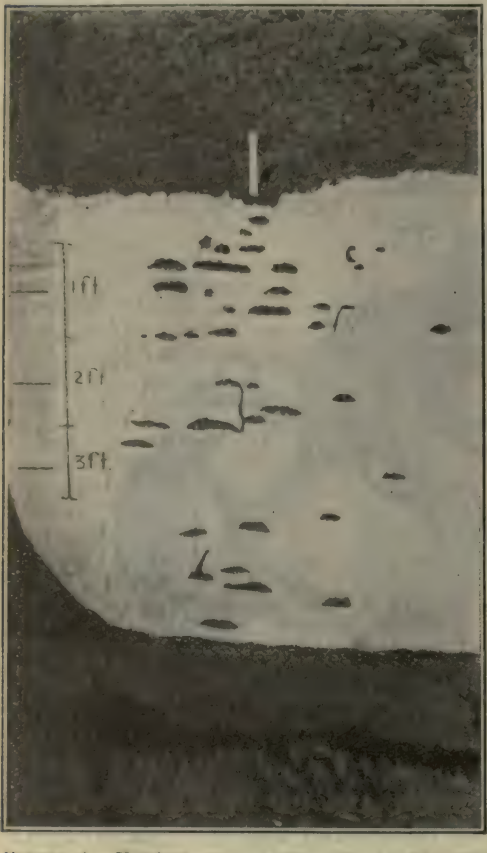

FIGURE 4.—Vertical cross section of an ant nest, showing the location and distribution of the chambers and a few of the connecting tunnels. The side of the excavated pit has been whitewashed so that the chambers will show more plainly. Note that these lie generally below the main entrance to the nest (marked by a stake). Such a colony can be destroyed by pouring 4 ounces of carbon disulphide down the main entrance

Another nest having a cleared area of the same size was excavated in 1928. This went to a depth of only 7 feet, at which point hardpan was encountered. This nest is shown in Figures 5, 6, and 7.

The type of soil affects the general arrangement of the tunneling. If the soil is porous, such as a sandy loam, for a considerable depth so that the nest can be extended downward uninterruptedly, the general shape of the tunneled area is that of a cone, usually from

8 to 10 feet in depth, with the apex or small end at the bottom. The ants are often checked by a hard layer of soil, which must approach the hardness of hardpan before it can stop these determined insects.

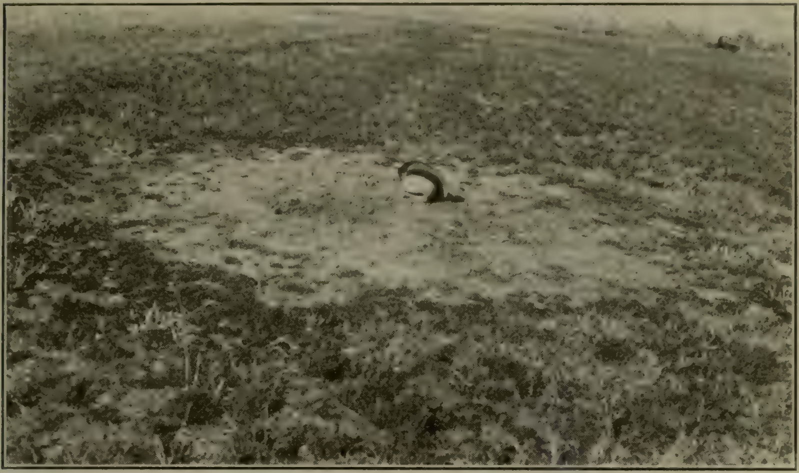

FIGURE 5.—The barren area, 12 feet in diameter, over a typical ant nest. The location of the vertical tunnels found on excavating this nest are shown in Figure 7

In this case the tendency is for the nest to spread laterally. A high-water table that interferes with the downward movement of the ants has the same spreading effect on the nest as a layer of hard earth. This is noticeable along ditch banks, where the water stops tunneling activity. In this case the nest exhibits a tendency to be narrow and to extend along the bank.

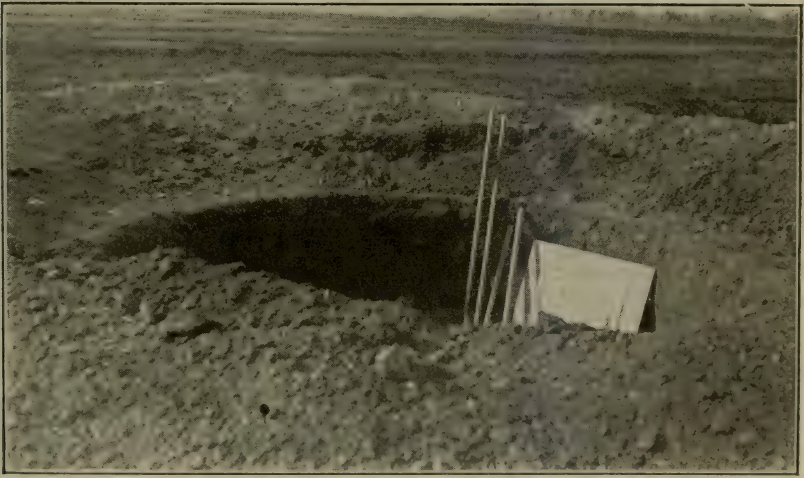

FIGURE 6.—Excavating an ant nest. This is the same nest as is shown in Figure 5. After removing each 6-inch layer of earth the locations of the exposed vertical tunnels were marked on a circle on the paper attached to the board. These circles, representing the excavated ring, with the tunnels indicated are shown in Figure 7. About 10,000 ants were found inhabiting this nest

ACTIVITIES OF THE COLONY

A new ant colony is established by a mated or fertile female, after the emergence of the winged forms at swarming time. The percentage of ant colonies that become successfully established is extremely small when compared to the number of virgin females that issue from an individual ant colony, as explained hereafter.

SWARMING

Swarming is the term used to designate the emergence and mating of the winged males and females. In southern Arizona this activity takes place usually in August and September, although it may occur at any time from June to October. It frequently takes place after a shower in the afternoon and is ordinarily completed the same day on which it is started.

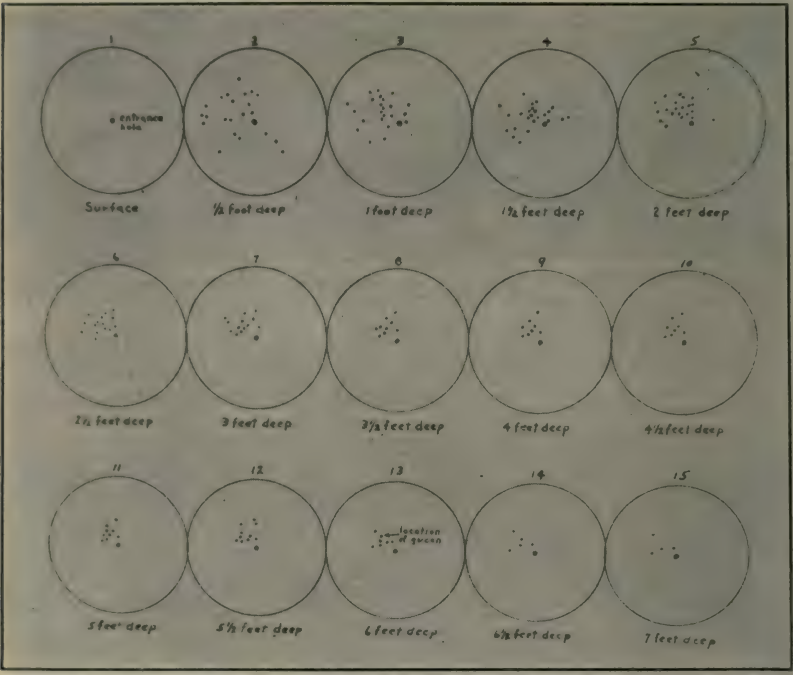

FIGURE 7.—Locations of the vertical tunnels in the nest shown in Figures 5 and 6: Each circle represents a cross section of the nest at 6 inches below the preceding circle. The nest was excavated to a depth of 7 feet. The queen was found 6 feet below the surface, as indicated in circle No. 13. Circle No. 2, the cross section exposed on removing the first 6-inch layer of soil, shows the holes which were treated with carbon disulphide before the nest was excavated further

Mating occurs soon after the winged forms emerge from the nest. Males and females may be seen by the hundreds gathered around the entrance hole, or climbing upon grass, sticks, rocks, or any other object projecting into the air, in their efforts to fly away. The act of mating generally takes place while the males and females are in flight.

During the swarming period male ants may be found congregated in large numbers on elevations in the vicinity of the colonies. The winged males often form a mass on the tops of low mountains or buttes or even on the tops of high buildings. Toward the end of the swarming period hundreds of dead males may be found piled up to such an extent that they may be scooped up with the hands. (Fig. 8.) The congregation of the winged forms at elevated points during swarming time is probably related to mating. Those males which are unable to mate soon after emerging from the nest alight on the higher places of vantage to wait for the virgin females to alight or pass by. Most of these males die soon after alighting because of their weakened condition after flying for considerable distances.

ESTABLISHMENT OF THE COLONY

The male dies soon after mating, but the mated female establishes a new colony. She removes her wings either by pulling them off with her mouth parts and legs or by rubbing against rocks, grass, sticks, etc. After removing her wings she immediately begins digging into the ground. She first excavates a hole about 10 inches deep, and then she usually constructs from one to four small dome-shaped chambers branching off from this. When this work is completed, the young queen plugs up the entrance hole with the last bit of dirt excavated. She then deposits a cluster of about 50 eggs which eventually become the first workers of the new colony. These eggs and the resulting larvae and pupae are necessarily taken care of by the young queen. She carries the eggs from one chamber to another so that they receive the proper temperature and moisture for hatching. When the eggs hatch she feeds the larvae a secretion which is derived from the fatty tissue of her own body. These larvae, after passing through the pupal or resting stage, develop into workers. These first workers, owing to the fact that they are reared on the limited amount of food

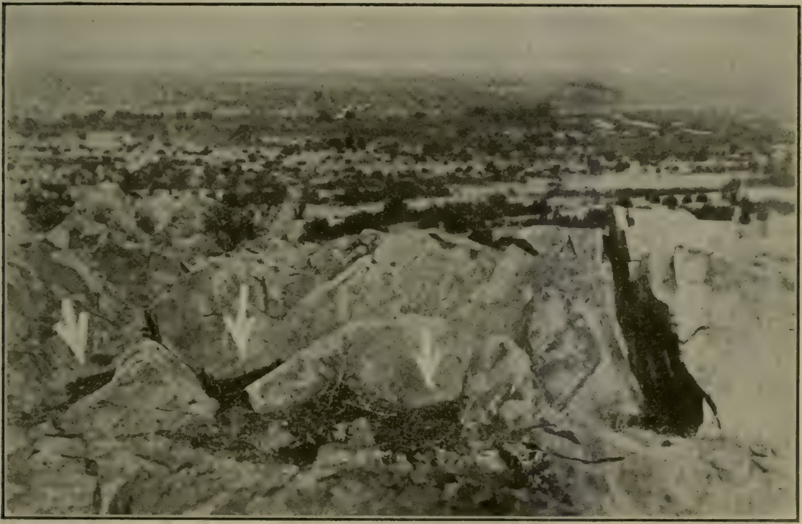

FIGURE 8.—Piles of dead male ants collected in the pockets of a rocky hill some 300 feet higher than the surrounding desert. The arrows point to the heaps of dead ants

from the queen's body, are small as compared with those that follow. The colony once established, the queen spends the rest of her life within the tunnels and chambers, shunning the bright light of the outside world. The queen mates only once during her lifetime.

The percentage of females which are able to establish new colonies that are strong enough to survive is exceedingly small. After a period of heavy swarming in the fall of 1928, an estimate of the number of queens which were attempting to establish new colonies on an 80-acre alfalfa field at Tempe, Ariz., showed that there were about 80,000, or 1,000 per acre. Observations made in the same field during 1929 failed to reveal any new colonies although a few probably survived. Several factors are responsible for this great mortality of females at swarming time. Many are eaten by birds, toads, etc. Undoubtedly a certain percentage fail to mate in their hasty flight. Thousands are unquestionably lost in their attempts to find suitable places in which to establish colonies. Probably the greatest factor in reducing the number of successful females is the lack of vitality sufficient to establish a colony that can survive adverse climatic conditions over the winter. The flooding of fields in irrigated districts or the occurrence of heavy rains also greatly hinders their attempts to colonize.

COLONY DEVELOPMENT

The new colony having been established by the young queen, the dirt with which she had plugged the entrance hole is removed by the workers matured from the first batch of eggs. In case the colony has been established in early summer the nest is opened up soon thereafter, but where swarming has occurred in late summer or early fall the new nest is not opened up until the following spring. In this last case a much larger percentage of the new colonies fail to survive the winter owing to lack of stored food. The small ants enlarge the nest by extending its tunnels and constructing new chambers. Food in the form of seeds is harvested and stored in some of the chambers, and the new colony becomes the scene of much activity.

When the first of the workers issue in the newly formed nest the queen again starts egg laying and limits her activity thereafter solely to this function. The workers, beside doing the work of expanding the colony, bringing in food, removing refuse from the chambers, and guarding against the intrusion of any undesirable visitors, also care for the eggs, larvae, and pupae, as well as actually feed the queen. The activities of the colony thus becomes specialized to the extent that the queen lays the eggs, while the work is carried on entirely by the workers.

The barren circular area (cover illustration and fig. 5), commonly called an "ant hill," surrounding the entrance hole of the colony is the result of the activity of the ants in cutting down any vegetation which attempts to grow there. The size of this circle depends on the tunneled area underneath the surface of the ground. The presence of vegetation on the surface would shade the colony, thereby increasing the amount of moisture within the nest, and moist chambers are not suitable as storage rooms since moisture is conducive to seed germination. Sprouted seeds are not desired as food by the ants and are accordingly carried out of their galleries to the edge of the cleared area on the surface of the ground, and there they are dumped. At the same time, by preventing the rays of the sun from reaching it, vegetation would reduce the temperature to an undesirable degree, thus making the chambers unsatisfactory as nurseries for the immature stages of the ant.

After the colony once becomes established, there is a gradual increase in its size for a few years until it reaches maximum development. The queen continues to lay eggs which produce an ever-increasing number of workers. The number of the chambers is increased, and their size is enlarged, as is the cleared area on the surface of the ground. Colonies ordinarily survive for several years. One colony has been under observation by the senior writer at Tempe, Ariz., for 19 years and is still active, and it appears that it may continue indefinitely unless some external condition arises to destroy it.

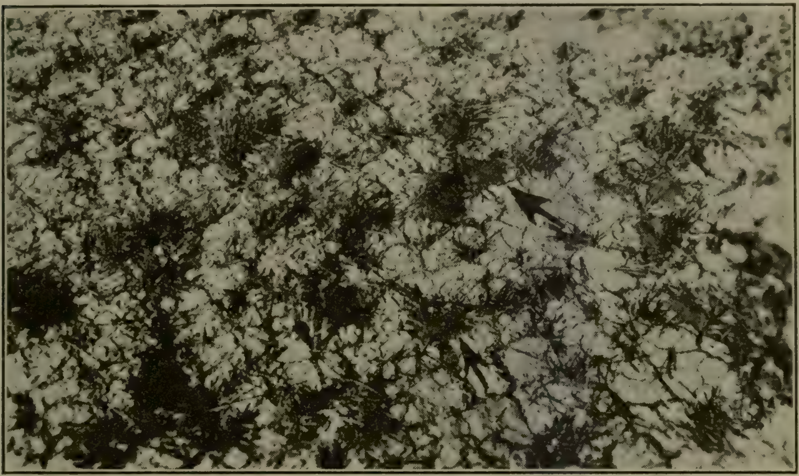

FIGURE 9.—Small piles of earth thrown out by new queens in their futile attempts to start new nests. No less than 12 different queens had made such attempts in this 3 by 4 foot area where only one colony could possibly have survived. Two of the piles of earth are indicated by arrows

LOCATION OF NEW COLONIES

New colonies are most easily established in fields having a porous soil or along ditch banks, where the soil is easily excavated. Where the soil is hard or rocky, the females are unable to penetrate to the desired depth, and failure is certain. An examination of an alfalfa field (fig. 9) revealed the presence of 50 unsuccessful new workings of young queens in an area of 60 square feet. Although the females may fly for considerable distances, it has been observed that by far the greater number of new colonies are established within a radius of a few hundred feet from the old colony.

FOOD AND FOOD STORAGE

The common name of the red harvester ant is derived from the ant's habit of going out into the field surrounding the nest and harvesting the seeds which are its principal food. (Fig. 10.)

Apparently any seed which can be carried is taken, and the variety largely depends upon the vegetation found nearest the colony. A number of different kinds of seeds have been found stored in the colony chambers, such as alfalfa, bur clover, Johnson grass, oats, wheat, Bermuda grass, wild sunflower, and mesquite beans. Such products as bran or rolled oats, when within reach of the ants, are often carried in by the workers. All food materials are stored in the chambers. This stored material is not confined to any particular part of the nest, but may be found in chambers scattered throughout. It is undoubtedly moved about from chamber to chamber as the space is needed for other colony activities. In the fall, when seeds are most numerous, a majority of the chambers may be found to be largely filled with stores. This habit of food storage is one that makes control more difficult and perplexing. An ant colony when treated with some substance may immediately become quiet, the entrance tunnel being closed up and the ants living on these stores for months at a time. As it shows no outside activity, one is led to believe that the colony is dead, but it may suddenly resume its workings and become as lively as ever.

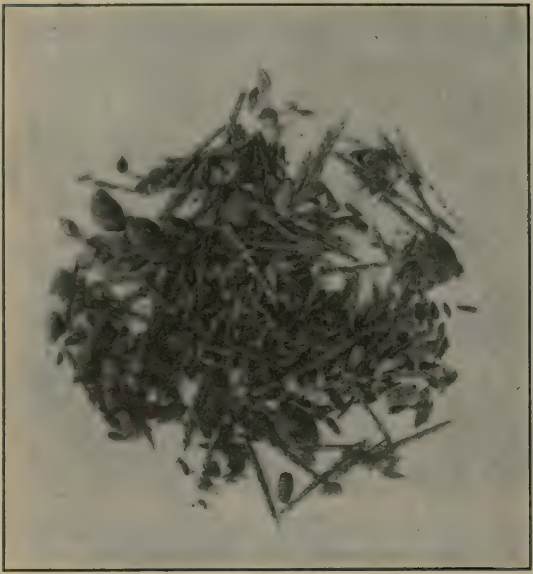

FIGURE 10.—Seeds of various plants found in the storage chambers of the red harvester ant. Among these are the seeds of Johnson and Bermuda grasses and alfalfa, and the beans from a mesquite tree. Although the ants prefer small seeds, the presence of the mesquite beans proves that these ants can transport large objects when the occasion demands. Natural size

DRESS PROTECTION AGAINST ANTS

The bites and stings of these ants affect some people more severely than others. In no case, however, is it a pleasure to be the recipient of an attack by these determined insects. While working among them, it is advisable to dress in such a way as to prevent their gaining entrance into the clothing and subsequently biting and stinging.

Rubber boots (fig. 11) serve as an excellent protection. The ants can not readily climb up the smooth sides and usually fall back to the ground soon after getting on the boot. Knee boots are much easier to work in and are just as much protection as hip boots, provided they have a really smooth surface.

Knee-high shoes with the trouser legs tucked inside afford considerable protection. The ants can occasionally ascend a shoe, especially where it is laced, so it is advisable to keep one eye, so to speak, on the footwear. Shoes that lace tightly so that the laced edges are drawn closely together are more desirable.

Any method which fastens the trousers tightly about the ankle, such as the wearing of leggins or tying the bottom of the trousers, is better than taking no precautions at all. It will be found necessary, regardless of the kind of protective measures taken, to stamp the feet on the ground at regular intervals to dislodge any ants that have started to climb the legs.

CONTROL MEASURES

The control of these ants, as has been previously mentioned, is extremely difficult. This is due to their tenacious habits and to the fact that their colonies are so well organized and their nest constructed so deep beneath the surface of the ground. It is, therefore, necessary first to determine and fix firmly in mind the general structure and extensiveness of the individual nest that is to be treated. The method of treatment must then be taken into consideration and the conditions under which it is to be applied. The degree of control obtained when using any given material is often deceiving, as previously explained (p. 12). Treatments applied in the fall of the year, about the time cold weather sets in, may cause the colony to enter a stage of hibernation which will continue until the following spring. Though this result will save much winter feed and consequently reduce the total yearly damage, it may not result in the final destruction of the colony. In this case, unless one digs down into the tunneled area of the nest, it is impossible to determine until the following spring whether or not the ant colony has been killed.

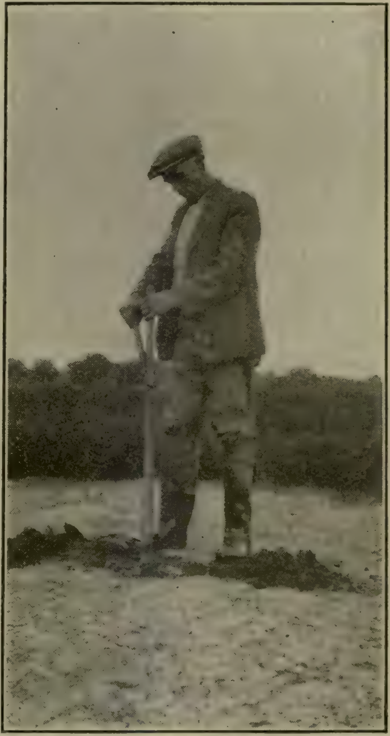

FIGURE 11.—When working around the red harvester ants, it is essential to take some measures to prevent their gaining access to the clothing. Rubber boots, such as are worn by this man, are a very satisfactory protection

Several materials give favorable control of the red harvester ant under certain conditions, whereas many others that from time to time have been recommended as remedies for this annoying pest have not been found to be permanently effective. No treatment which does not kill the queen will result in the permanent destruction of the colony. The queen, being the egg-laying machine, will soon replace the workers that are killed, and in time the colony will again be as strong as ever. On the other hand, a treatment which destroys the queen and a majority of the workers at a time of the year when there are no young in the colony in the form of eggs, larvae, or pupae, will effect a complete control, as the few remaining workers will eventually die and there will be no young ants left to continue the colony.

MEASURES AND MATERIALS RECOMMENDED

There are two substances which, when properly applied, give a higher percentage of control than any of the many other methods tried. These are carbon disulphide and London purple.

CARBON DISULPHIDE

Carbon disulphide is a colorless liquid which can be purchased at drug stores and seed houses, at prices ranging from 1 to 2 cents an ounce. When purchased in 5-gallon or larger quantities, it can be obtained at reduced prices. About 4 ounces of carbon disulphide is necessary for each application in treating a colony. The cost, therefore, not including labor, amounts to about 4 cents per nest as a minimum. Four fluid ounces of carbon disulphide is the amount recommended for destroying a colony of average size. A colony showing unusual strength and size should be treated with more than 4 ounces, but experiments have shown that for an average-sized nest this quantity will give about the same results as quantities up to a pint.

Carbon disulphide is very inflammable and explosive. It should be handled with great care, with assurance that no fire in any form is close by. A container of this material should never be opened in a closed room where there is little air in circulation as its fumes are deadly to human beings as well as to ants. When not in use, carbon disulphide should be kept well sealed and in a cool place. If handled deliberately and carefully, there is no danger connected with its use.

Carbon disulphide is best applied during either the early spring or the late fall of the year, while the ants are still actively working. The treatment should be made either in the early morning hours or late in the evening when practically all of the ants are within the colony, since if it is made in the middle of the day, during the time that the ants are out foraging, those not in the nest will escape death, and in case any eggs in the nest are not destroyed, the ants would rear a new queen. Carbon disulphide should not be used in the middle of the summer as it volatilizes too quickly in hot weather and would diffuse into the air currents and its effect be lost. It is advisable to apply this material when the ground is in a moist condition since this assists in the diffusion of the gas downward. The fumes or gas given off by it, being heavier than air, flow down through all of the tunnels of a colony and this makes it the ideal material for killing these destructive pests.

The thing to be aimed at for successfully controlling an ant colony is to apply the carbon disulphide in such a way as to allow the fumes to drain downward through the entire colony. Three methods of applying this material have been found to be successful. The first of these calls for the removal of a layer of dirt about 6 inches deep and from 2 to 3 feet in diameter, depending on the size of the colony, immediately around the main opening to the nest, and the pouring of the liquid down the several tunnels that will then appear as small holes about the diameter of a lead pencil. The second and simplest method is to pour the liquid directly into the entrance hole or holes.

The third method is to place the liquid in a shallow pan or dish beneath a tub that has been inverted over the main entrance to the nest. The edges of the tub should be pressed close to the ground, but it is not necessary to close the opening to the nest after making the application.

Of these three methods, the first, that of removing several inches of the top soil before applying the liquid, is the most certain to be effective with one treatment. If this is properly done, and at the right time, nearly all of the ants will be killed by the first application. It is advisable in these treatments to remove the surface soil one day and make the application the following day. This gives the ants a chance, during the interval, to clean out any soil particles that may have dropped into the tunnels. The majority of the downward tunnels leading directly to the various portions of the nest should be found and given a share of the dose, for only in this way can a complete fumigation result. The only objection to this method is that it requires more labor than the others, and the operator will need to be dressed as recommended in the section on Dress Protection Against Ants, in order to protect himself from these disagreeable pests. One will be better repaid, however, for the time and pains required to make one application by this method, than by using either of the other less certain methods, especially in the case of colonies in orchards where the crop to be protected is of high acreage value, or near the house where a large colony is extremely disagreeable.

The second method, that of pouring the carbon disulphide down the entrance hole or holes, is often quite successful when care is taken to pour the material slowly down the hole into the nest and then stamp the hole shut with the heel of the shoe. The colonies should be examined after a few weeks and the application repeated on any that were not killed. This method is not so successful as the one previously described because of the fact that the main opening to the colony may not be immediately above the center of the nest, and, the down tunnels being to one side, the fumes lodge in the network of tunnels and chambers near the surface of the ground before reaching the tunnels leading directly downward into the lower portion of the nest; or the fumes may drain into one part of the nest, leaving the other part free from them so that a great many of the workers and possibly the queen may escape uninjured. If the soil is quite shallow and there is a hardpan only a few feet beneath the surface, this method is usually fairly successful.

The third method, that of placing the desired dose of carbon disulphide in a shallow dish under a large inverted tub, is one that can be used quite generally around dooryards or residences. A galvanized washtub serves this purpose admirably. A pan of the liquid should be placed under the tub, and moist earth or mud should be plastered around the edges of the tub, so that the fumes can not escape but will be forced to go down into the nest. There is the same objection to this method as to the preceding in that a portion of the colony may escape by not being located immediately beneath the main opening.

LONDON PURPLE

The control of the red harvester ant by the use of London purple, though not so successful in destroying colonies, is in reality much cheaper than destroying them by the carbon disulphide method as it involves no apparatus and comparatively little labor. If thoroughly and correctly applied, it will give satisfactory results. London purple is a poisonous finely divided purple powder which is a by-product of the aniline-dye industry. In the past there was considerable variation in the proportion of arsenic, which is the poisonous agent of the compound, with a resulting uncertainty in its effectiveness. Within the last few years, however, this fault has been largely corrected. This poison is readily obtained in any locality at drug stores or seed houses. The material is a stomach poison, killing the ants when taken internally with their food. Death is not rapid, and results will not be noticed until two or three days after the material has been applied, at which time live ants may be noticed carrying the first dead ants to the outside rim of the cleared area over the nest.

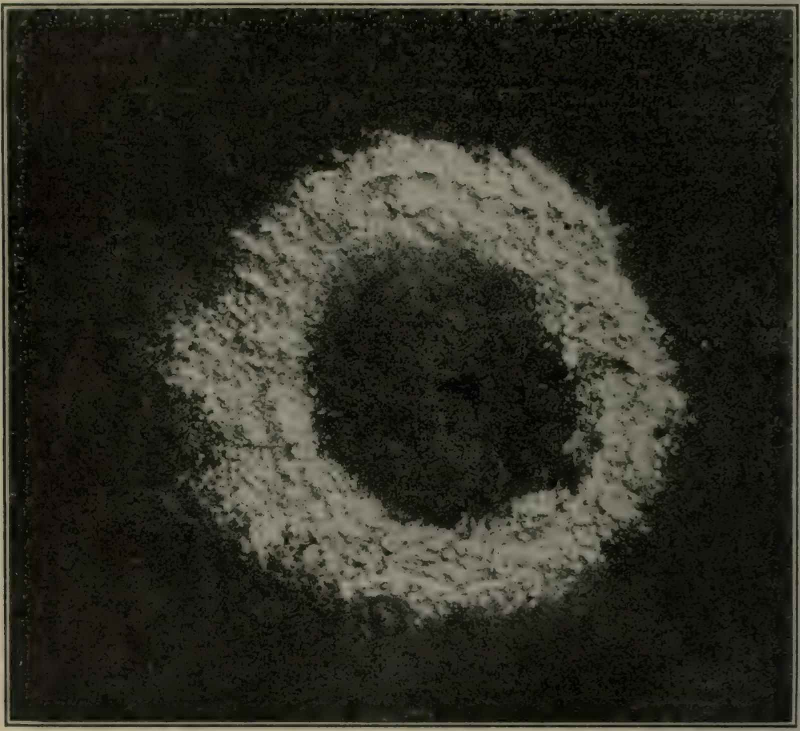

FIGURE 12.—A ring of London purple properly applied around the entrance to an ant nest. This ring should have a band of the poison that is 1½ inches wide, with the inside edge of the circle not more than 2 inches from the hole or entrance to the nest

London purple is most effective and should be used during the period of greatest activity of the ants. In late spring or at any time during the summer is the best time to apply it. During this period the ants are replenishing their depleted stores, and the poison is readily carried to the food supply. About one-half ounce of the poison should be applied in a circular band around the entrance hole or holes to the nest. This band should be not wider than 1½ inches and the circle made by it should be about 4 inches in diameter. The band must be unbroken, so that it will be impossible for the ants to go in and out of the colony without going through the London purple. One-half ounce of material will make a very shallow ring.

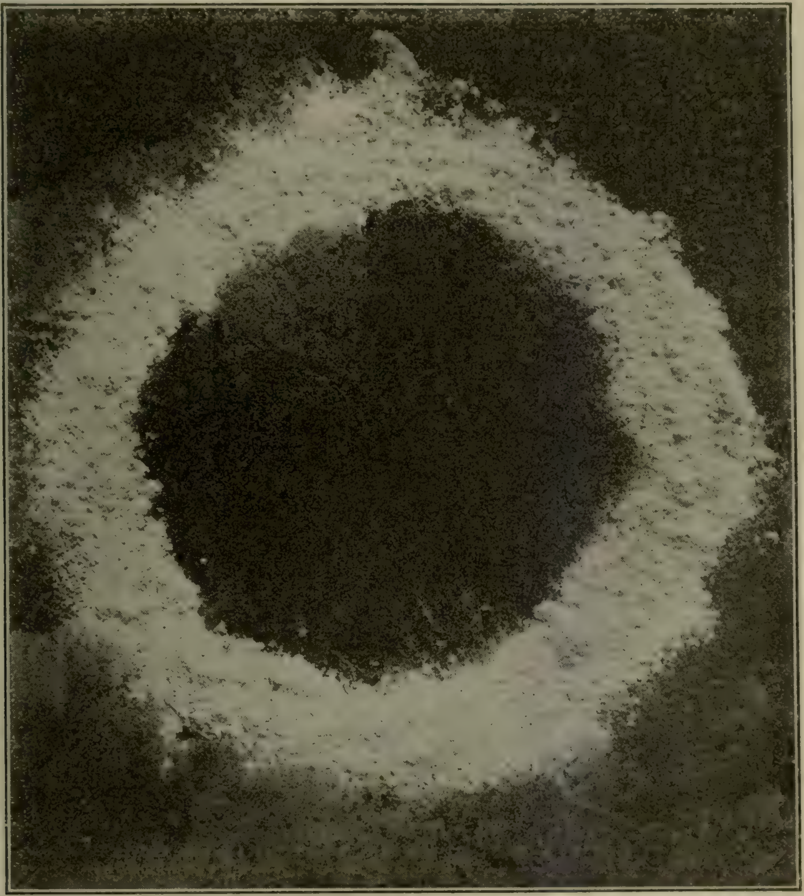

FIGURE 13.—A ring of London purple improperly applied around the entrance to an ant nest. When the poison is placed too far from the opening it is often shaken off by the ants before they enter their nest

The powder should be applied as shown in Figure 12 and not as shown in Figures 13 and 14. The use of London purple is often unsuccessful because of the failure to apply it properly. If the band is too far away (fig. 13) the ants will knock too much of the London purple off of their feet and bodies between the ring and the opening to the hill. If the material is placed directly at the opening (fig. 14), they will often not go through it but will make a new opening to the nest. If too much purple is applied and the band is too deep they will hesitate to walk across it and instead may open up a new hole, just as they would if the main entrance were plugged with the London purple.

In order for this poison to be successful, the application should be repeated at least three times, and as many more times afterwards as seems necessary on those colonies not controlled by the first three applications. The second and third applications should be made at intervals of from 10 to 12 days. This is necessary because when the poison is carried into the colony it does not kill the eggs or pupae. Consequently, even taking it for granted that all of the workers and the queen were killed by the first application, the pupae upon changing to adults will take care of the larvae hatching from the eggs and rear a new queen, and the colony will be continued and will soon build up to its old-time strength. By making the second and third applications, the adults developing from the pupae and the larvae hatching from the eggs laid by the old queen will also be killed, and the colony should be destroyed.

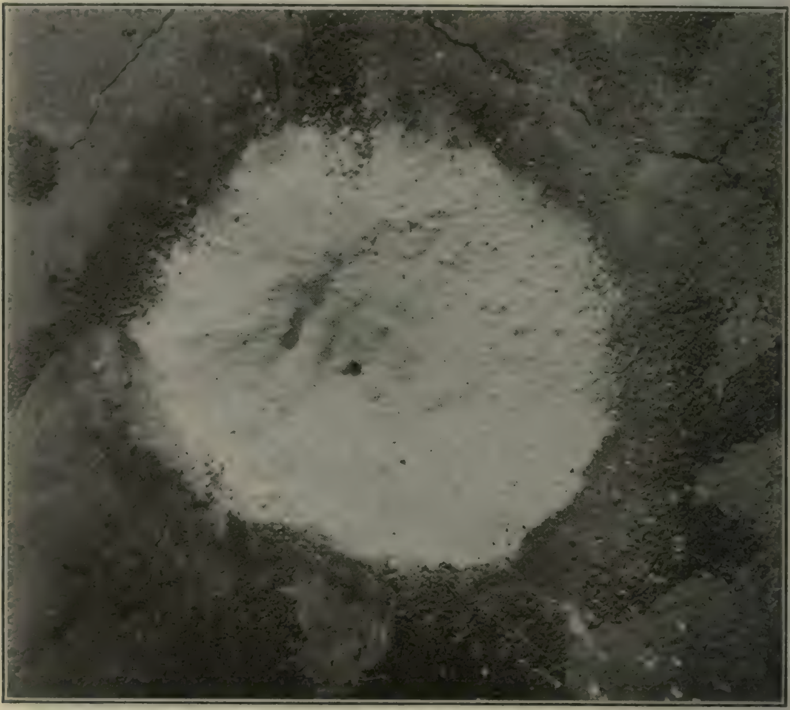

FIGURE 14.—London purple placed directly around the entrance to an ant nest. This is bad practice as it causes ants to dig a new entrance, and the poison is wasted

Only a portion of the colonies will be actually destroyed by these three treatments, and the process will have to be repeated from time to time and from year to year. The ant colonies can be successfully controlled, however, at a minimum of expense by this method. An 80-acre ranch, which contained 518 hills at the beginning of a 3-year experiment, contained only 160 active hills at the end of this period, and these were small and caused little damage. The entire expense in labor and material of the treatments, 13 in number, on these 80 acres amounted to $78.77, or 98 cents per acre for the three years. The material alone cost $35.47.

It may frequently happen that soon after applying a ring of London purple to an ant colony a sudden summer rain may fall and wash away the material. In this case, of course, it becomes necessary to repeat the application.

As London purple is an arsenical poison it should be handled carefully, and no empty cartons should be left lying in fields where livestock are present or around door yards where children might pick them up.

MEASURES FOUND PARTLY SATISFACTORY

Several methods of treating the red harvester ant are occasionally used which may serve the purpose of temporarily retarding their activities. None of these methods, however, will destroy the colonies, but because of the tendency of a colony to become inactive when treated in the summer or to go into hibernation when treated in the late fall, an inexperienced person may often be deceived into believing that the colony has been destroyed.

ETHYLENE CHLORIDE

Ethylene chloride, which is a colorless liquid very closely resembling carbon disulphide, will control ants in much the same manner. The material is applied in the same way under similar conditions, but it does not vaporize quite as rapidly as carbon disulphide and therefore does not show the same effectiveness in cool weather. Ethylene chloride, being more costly and difficult to obtain, as well as not being quite so effective, should not ordinarily be substituted for carbon disulphide.

TRAPPING

"Jugging" is a term used to designate a method of trapping the ants in which a jug, bottle, jar, or similar vessel, is buried close to the entrance hole with the mouth level with the ground. Many of the ants will fall into this, and the number of workers may be reduced to a point where they will cease to be an annoyance, especially where the colony is close to a dwelling, but it is by no means a method which will always destroy a colony.

CYANIDES

Calcium cyanide and sodium cyanide, especially the former, which is a commercial product used to kill insects, are quite commonly used to destroy ant colonies. Either may be purchased in powder, granular, flake, or lump form. These materials are quite different in their methods of releasing the deadly hydrocyanic acid gas. Calcium cyanide releases the gas quite rapidly when exposed to the atmosphere, whereas sodium cyanide absorbs moisture and gradually dissolves, giving off the gas much more slowly. Though unlike in this respect, their action when applied to an ant nest is quite similar, and they are therefore discussed together. Hydrocyanic acid gas is very deadly to ants as well as other animals and human beings, but owing to the fact that the gas is lighter than air it will not sink down into the colony more than a few inches beyond the point of application, and even though hundreds of dead ants are noticed at the entrance to the nest, complete control is not obtained. When it is desirable to check the activities of the ants for a short period of time, it may be done by placing a few ounces of calcium cyanide around the entrance hole or by making a solution of sodium cyanide and pouring it down the hole. The ants which pass near will be quickly killed by the fumes, and colony operations will be suspended for a week or more. In extensive tests with both sodium cyanide and calcium cyanide applied in many ways and under different conditions these substances failed to destroy any colonies completely.

Cyanide in any form should not be handled, nor should the container be opened in a closed room, and great care should be taken not to get even the smallest particle into the mouth or eyes as it is a dangerous and deadly poison. Animals or children should not be permitted to come in contact with it. Keep the container closed securely.

PARIS GREEN

Paris green may be used in the same way as London purple, by placing it around the entrance hole. The killing agent contained in it is also arsenic, and when the Paris green is tracked into the colony and mixed with the food many ants are killed. In some instances Paris green seems to have given results similar to London purple, but it has not generally proved so satisfactory, and it is doubtful if it should ever be substituted for this poison.

USELESS MEASURES OFTEN SUGGESTED

Several ineffective measures are often suggested or used as a possible means of control. These attempts at control are usually the result of insufficient knowledge of the structure of the nest and conditions affecting treatments.

Flooding, especially in irrigated districts, is occasionally tried as a means of combating the ants. Colonies that are flooded will temporarily discontinue activity on the outside of the nest, but will eventually become as active as ever.

Occasionally attempts are made to destroy ant nests by mechanical means. Some of these are plowing the surface soil, stamping entrance holes shut, filling dirt over the colony, and dynamiting. These practices have very little value and merely result in lost time and effort.

Oils, such as coal oil, gasoline, and lubricating oils, poured into the entrance hole of a colony are of no avail because they do not flow far enough into the colony to be effective.

Poisoned baits appear to be useless against this ant. Rather than carry the bait into the colony, the workers carry it to the edge of the cleared area on the surface and dump it.

INEFFECTIVE CHEMICALS

Nitro-benzol, a yellow, poisonous liquid, has no effect on the colonies of the red harvester ant.

Tartar emetic is a deadly poisonous substance, but it is ineffective because of the impossibility of getting the ants to take it internally.

Paradichlorobenzene is a material somewhat resembling table salt in appearance and commonly used as an insecticide and repellent. It has no value whatever against the ants. It produces a poisonous gas, but this gas does not penetrate the nests.

Lead arsenate and white arsenic are poisonous substances, which when applied in the same manner as London purple, have not proved effective.

SUMMARY OF RECOMMENDED CONTROL MEASURES

Carbon disulphide poured into the various tunnels, after a 6-inch layer of the topsoil has been removed, destroys a colony most quickly and thoroughly. The treatment should be applied in the spring or fall of the year and never at midday. The same chemical poured directly into the entrance hole frequently gives good results, but it is often necessary to repeat the treatment.

The application of London purple in a ring around the entrance hole is a cheap method of control and gives good results when used over a sufficient period of time. A season or two, or possibly longer, may be necessary to rid a field of the ant colonies present. It should always be applied when the ants are active, preferably during the late spring or summer.

Calcium cyanide sprinkled about the entrance hole serves to suspend the activity of the ants for a period of about a week or more. A second application continues the inactivity of the colony for a longer period.

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U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1669

FARM TERRACING

SOIL EROSION, which annually causes enormous losses to the farmers of the United States, is effectively controlled on moderate slopes by terracing. Two types of terrace—the Mangum and the level—are generally found best adapted to conditions in the United States. The Mangum terrace is a broad-base, ridge type of terrace with a uniform or variable grade; the level terrace is similar except that it has no grade. Both can be crossed readily by modern farm machinery and without injury to the terraces. They may be planted to crops and cultivated in the same manner as the rest of the field.

The level terrace is most nearly an ideal terrace. Its distinct advantage over the Mangum terrace is that it holds practically all of the soil and fertility on the field. It is particularly adapted to deep, open, permeable soils. When used in connection with tile drains it can be employed on practically any type of soil, and unquestionably is the most effective method known to check erosion and conserve moisture.

The Mangum terrace possesses all the advantages of the level type except that some of the fertile soil that is washed from the slopes and deposited in the terrace channel is carried off the field in the run-off water. The Mangum terrace can be used on any type of soil, but is particularly recommended where the level terrace can not be used successfully without tile drainage.

This bulletin is a revision of and supersedes Farmers' Bulletin 1386, Terracing Farm Lands.

Washington, D. C. **Issued July, 1931**

FARM TERRACING[1]

[redacted] *Senior Drainage Engineer, Bureau of Agricultural Engineering*

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INTRODUCTION

IT IS ESTIMATED that erosion removes not less than 126,000,000,000 pounds of plant-food material from the fields and pastures of the United States every year. This is more than 21 times the amount removed by crops, according to an estimate of the National Conference Board. The annual financial loss to farmers probably amounts to about $200,000,000.

A test of crop yields on the department's soil-erosion experiment farm near Guthrie, Okla., on two comparable areas of eroded and virgin land with moderate slopes, resulted in a yield of 40.3 bushels of oats on the virgin land and a yield of 10.6 bushels on the eroded land. As the eroded land had been in cultivation about 30 years some of the difference in yield may be attributed to that fact. At a price of 45 cents per bushel for oats, the difference in the returns from the two areas would amount to $13.36 per acre. The cost of controlling erosion by terracing on badly gullied land that had been in cultivation about 35 years on the Guthrie farm was more than three times as great as on virgin land. This indicates the advisability of starting the control of erosion on virgin land when it is first broken rather than waiting until the land has become badly eroded and unproductive.

In regions of light rainfall, terraces serve also to conserve moisture. The results of experiments on the Oklahoma Agricultural Experiment Station farm at Goodwell, show that terracing to conserve the moisture on a land slope of only 2 feet in 100 feet increased wheat yields on an average of 21 per cent during a period of four years. On the Texas Agricultural Experiment Station farm near Spur, it was found that terracing increased crop yields from 20 to 40 per cent during a 3-year period.

Erosion injures fertile lands in a number of ways.[2] The upper and most fertile parts of the soil are washed away until the land becomes barren and unproductive. (Fig. 1.) Deep gullies[3] are formed which mean an actual loss of cultivable land area, and result in a lowering of the water table and a deficient supply of moisture.

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[1] This bulletin is based in part on studies conducted in cooperation with the Bureau of Chemistry and Soils.

[2] For a rather full discussion of the damage being wrought by soil erosion the reader is referred to Department Circular 33, Soil Erosion a National Menace.

[3] It is recommended that this bulletin be read in conjunction with Farmers' Bulletin 1234, Gullies, How to Control and Reclaim Them.

(Fig. 2.) Drainage ditches often become filled with sand, which frequently results in the flooding of the adjoining bottom land and the destruction of crops. (Fig. 3.) Rich bottom lands often are covered by deposits of sand washed from the hill lands. (Fig. 4.) Hence, the direct erosion losses of the upland farmer are the loss of the land area occupied by gullies, smaller crop yields each year, and continued decrease in the market value of the land. Some of the losses suffered by the bottom-land farmer are, cultivable land covered with sand, crops damaged by overflows or deposits of sand,

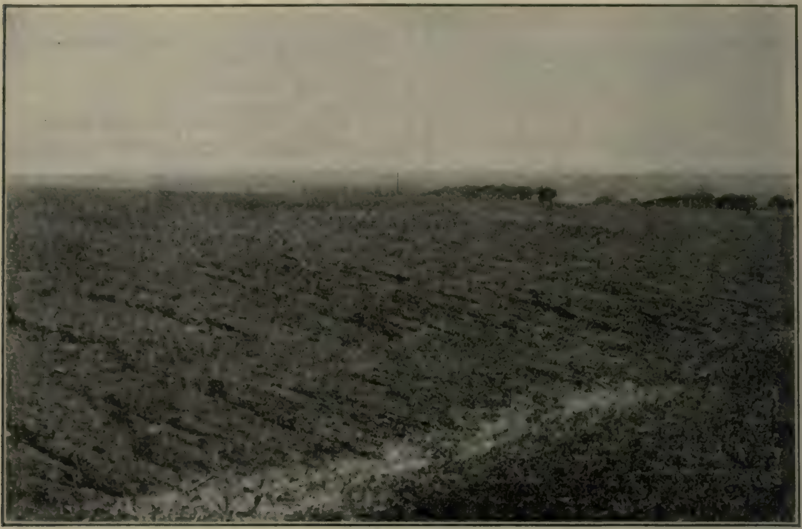

FIGURE 1.—Sheet erosion on a moderate slope in a wheat field. Note the strip of land in the center, rendered unproductive through sheet washing

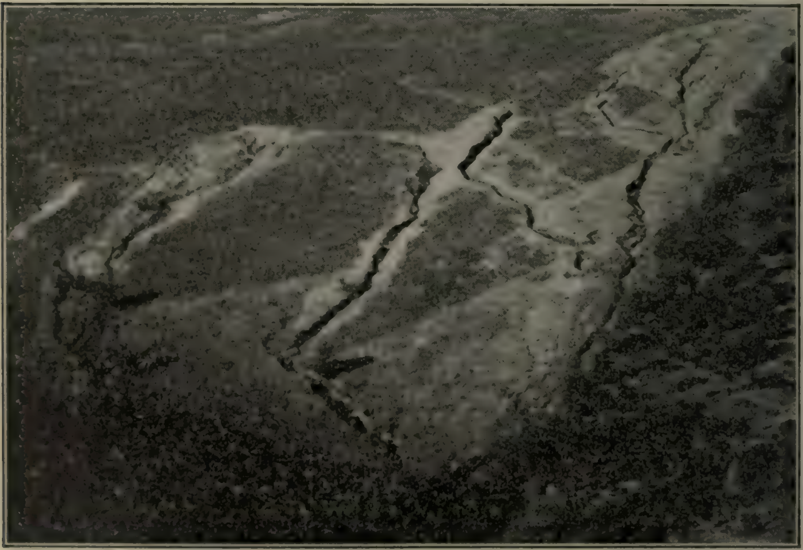

FIGURE 2.—View from an airplane showing gullying which causes a loss of land and a lowering of the water table

continued decrease in the market value of the land, and the money invested in the construction of drainage ditches that have been wholly or partly filled with sand. Thus it is clear that both bottom-land farmer and the upland farmer should be concerned in effective measures for checking erosion.

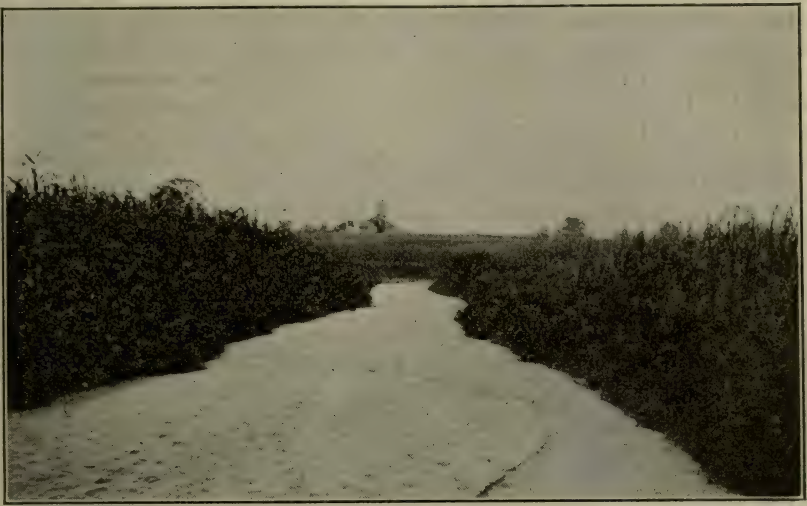

FIGURE 3.—Drainage ditch partly filled with sand washed from eroding hills

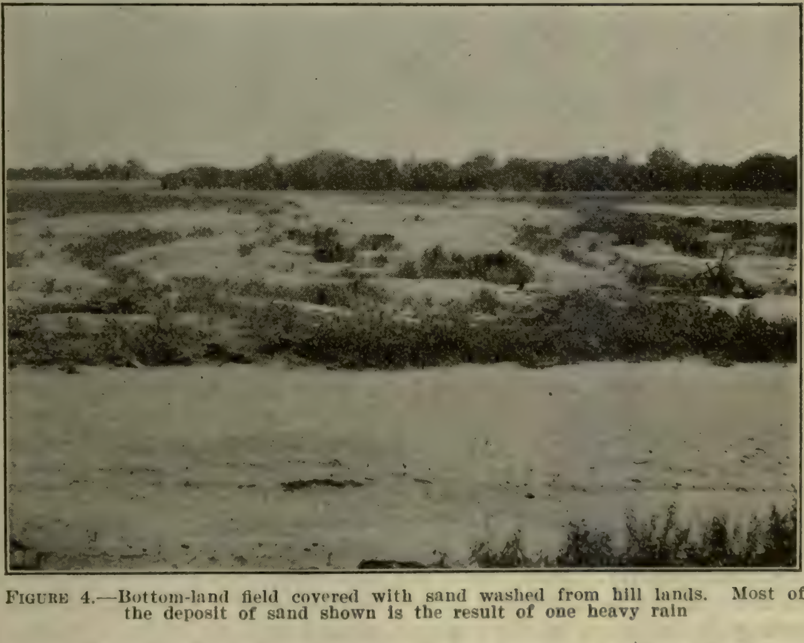

FIGURE 4.—Bottom-land field covered with sand washed from hill lands. Most of the deposit of sand shown is the result of one heavy rain

Erosion is caused chiefly by the direct action of heavy rains beating upon the ground; by the rapid movement of the rain water down the slopes of the land surface; and by the combined action of the freezing and thawing of saturated soil, followed by heavy rains.

(Fig. 5.) The steeper the slope the greater is the erosive action of running water.

Where the moving water is fairly uniformly distributed over the surface, the upper soil is washed away over wide areas; this form of erosion is known as sheet washing. (Fig. 1.) Where channels are washed down the slopes, by the concentration of large volumes of water, gullying occurs. This type of erosion generally begins in depressions or draws. (Fig. 2.) Sheet washing is not so noticeable as gullying, and for that reason many farmers do not consider it very harmful. However, it is very destructive, since it robs the land of the surface soil, which is known to contain a higher percentage of plant food than does the subsoil. Also, it is practically impossible to obtain the full benefit of expensive fertilizers and manure where sheet washing is permitted to occur since they are rapidly washed away along with the surface soil. If sheet washing were prevented, few gullies would ever occur in a field, because sheet washing finally develops into gullying.

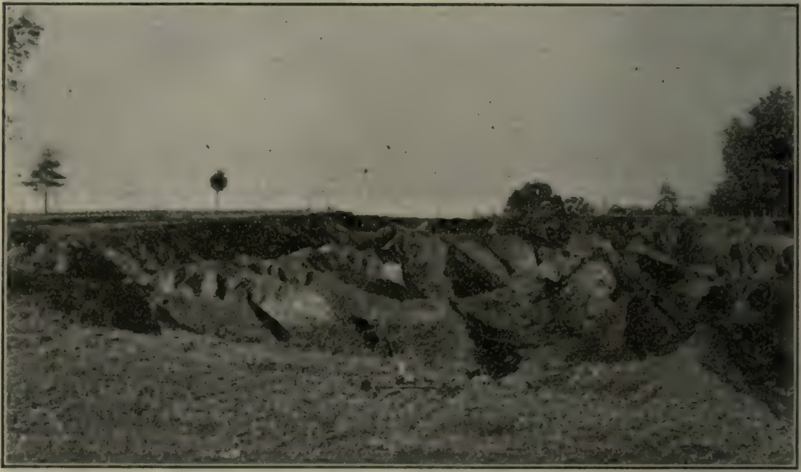

FIGURE 5.—Erosion on very silty soils which practically ruins broad areas of fertile land. Alternate freezing and thawing hasten the rate of erosion over such areas, particularly in the South

METHODS OF PREVENTING EROSION

Since erosion is caused largely by the rapid movement of rain water over the surface of the ground, methods of preventing erosion must be directed toward causing the water either to sink into the soil or to flow away slowly over the surface to a drainage channel.

In order to take up surface water rapidly a soil must be very permeable, which means that it must contain fairly large open spaces through which the rain water can pass easily, or in which it can be stored temporarily. Some soils are naturally very permeable; those that are not can be rendered more permeable by subsoiling or deep plowing; by plowing under organic matter such as manure, stubble, stalks, and cover crops; and by the practice of tile drainage.

Vegetation which covers the surface of the ground protects the soil from the direct action of the rain and checks the flow of water over the surface, thus giving the soil a better chance to absorb the water. It is therefore important that some kind of cover crop such as vetch, clover, oats, wheat, or rye be grown during the winter or at any time that the land is not used for other crops.

Contour plowing—which consists of breaking the ground along level lines across the slopes—reduces the flow of water directly down the slope. In planting and cultivating the crops the same level lines are followed, so that a shallow trough is made above each row, which catches and holds some of the rain water until it is absorbed by the soil. A great many gullies are caused in the beginning by the practice of plowing and cultivating directly up and down the slopes. (Fig. 6.)

THE MANGUM TERRACE

The Mangum terrace consists of a broad ridge of earth thrown up across the hillside and having a grade in the direction of its length. (Fig. 7.) In throwing up this ridge a broad, shallow channel is formed along its upper side, through which the collected water flows at low velocity to the outlet channels at its ends. (Fig. 8.) The entire terrace is cultivated, and on moderate slopes the crop rows may run at an angle across the terraces (fig. 9), although better results are obtained when the rows are parallel with them.

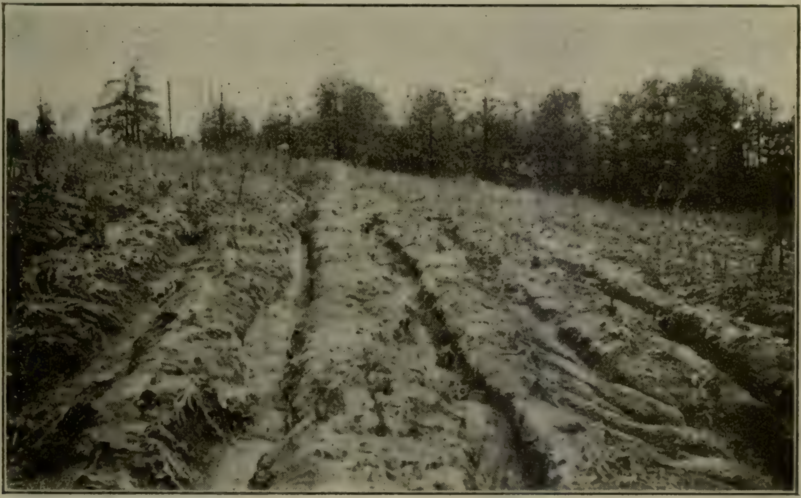

FIGURE 6.—Erosion due to running cotton rows directly up and down the slope, a practice which is responsible for a large percentage of badly eroded lands

HEIGHT

The top of the Mangum terrace should be from 15 to 24 inches higher than the bottom of the channel on the uphill side of the terrace. The terrace should be built ordinarily from 15 to 30 feet wide at the base, depending upon the slope of the land; the steeper the land the narrower the base. Wide terraces are the more desirable from the standpoint of crossing them with farm machinery. The width may be increased each year by throwing the soil to the center of the terrace in plowing until, on moderate slopes, the lower edge of one terrace meets the upper edge of the next terrace below, and the whole field, as often happens, becomes a series of terraces.

GRADE

In most soils it has been found that washing in the channel of the Mangum terrace takes place when the grade of the terrace is greater than 6 inches in 100 feet, and even with this grade some of the fertile parts of the soil are carried away by the water. It is therefore advisable that there be as slight a grade as is practicable and never more than 6 inches in 100 feet.

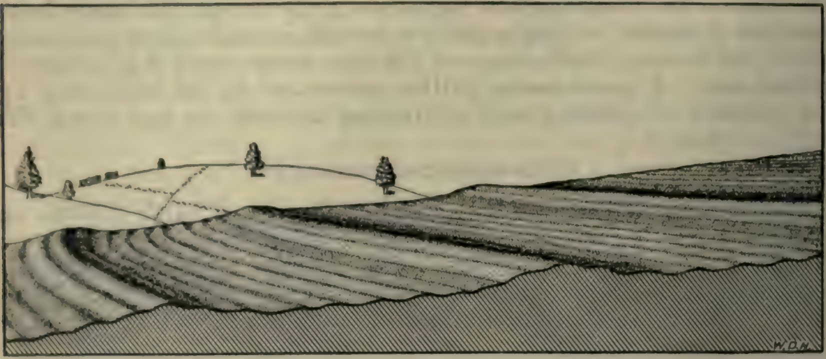

FIGURE 7.—Mangum terraces. These are simply ridges of earth thrown up across the hillside and given a slight grade in the direction of the terrace to carry off the water at a low velocity

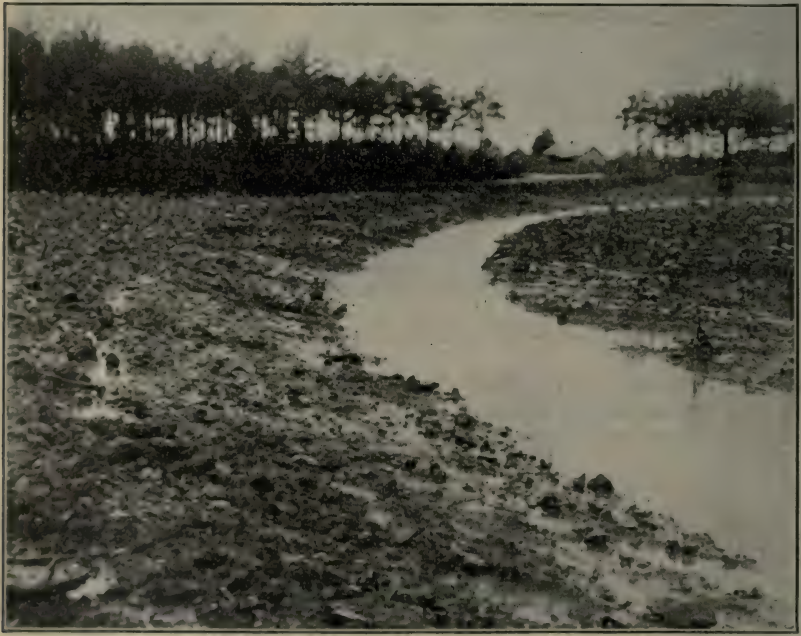

FIGURE 8.—Water flowing off at a low velocity in a broad, shallow channel of a Mangum terrace

The grade of a terrace refers to its drop in 100 feet of length and may be either uniform or variable. By a variable grade is meant one that increases from the upper to the lower end of the terrace. A variable-graded terrace is superior to a terrace with uniform grade, since it removes the surface water with less washing in the terrace channel and with less probability that the terrace will break near the lower end owing to the piling up or concentration of the run-off water. Also if the upper part of a terrace has less grade than the lower part, the tendency is to store or hold back the upper water until the water below has a chance to flow off.

A good practice is to change the grade every 300 feet along the length of the terrace. The following tabulation gives grades suitable for use in laying out Mangum terraces with variable grade. If it is necessary to lay out a terrace longer than 1,500 feet it should be built higher for the additional length near the lower end, or else the terraces should be placed closer together than is indicated in the tabulation on spacing in the paragraph below. Either of these precautions is preferable to increasing the grade above 6 inches per 100 feet.

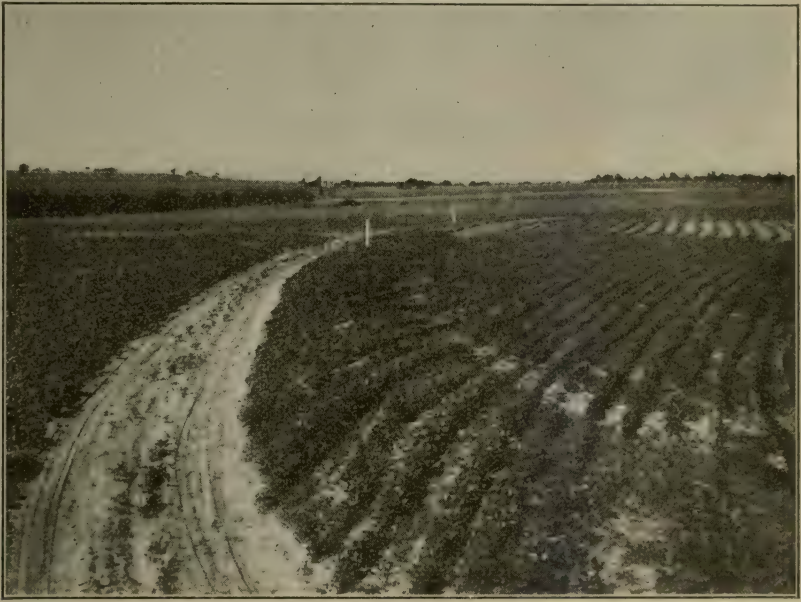

FIGURE 9.—Soybeans planted in rows across a Mangum terrace

Length of terrace	Drop of terrace in 100 feet of length
0 to 300 feet	½ inch.
300 to 600 feet	1 inch.
600 to 900 feet	2 inches.
900 to 1,200 feet	4 inches.
1,200 to 1,500 feet	6 inches.

SPACING

The vertical distance, or drop, between Mangum terraces depends principally upon the slope of the land. Terraces should be spaced close enough to prevent appreciable washing between them. The following tabulation gives the vertical distances between terraces recommended for use on different slopes.

Slope of land per 100 feet	Vertical distance, or drop, between terraces[4]
Less than 1 foot	1 foot.
1 foot	2 feet.
2 feet	2½ feet.
4 feet	3 feet.
6 feet	3½ feet.
8 feet	4 feet.
10 feet	4½ feet.
12 feet	5 feet.
14 feet	5½ feet.

LIMITING LAND SLOPES

Where modern machinery is used in cultivating the land, the Mangum terrace is adapted for use on slopes of up to 10 feet in 100 feet. On steeper slopes there is difficulty in crossing these terraces with machinery. Where such equipment is not used Mangum terraces have, in certain instances, proved successful on slopes of as much as 15 feet in 100 feet. However, as a general rule it is advisable to leave slopes with a fall exceeding 12 feet in 100 feet in hay, pasture, or timber.

CAUSES OF FAILURES

Failure of Mangum terraces occurs most commonly at sharp bends, at crossings of draws or gullies, and at points where either an abrupt reduction in grade or size of channel has been made. Breaks at bends are caused by water washing against the terrace and cutting through the embankment of earth and occur commonly where the terrace has considerable grade and the water a high velocity. Such breaks may be prevented by seeding the terraces to grass at bends and on areas where there are sudden changes in grade and thus leaving them uncultivated. Breaks at crossing of gullies or draws are usually caused by failure to build the top of the terrace to the proper height across such places or by not making the proper allowance for the settlement of the terrace. The grade of the top of the terrace leading into a draw never should be greater—and preferably should be less—than the grade of the top leading out, because a greater grade above would result in much more water being brought into the draw than could be carried out on the lighter grade.

THE LEVEL TERRACE

In all terraced fields some washing is bound to occur on the slopes between the terraces. The rich soil particles washed from the slopes collect in the channel above the lower terrace. If the terrace has a grade, part of the soil is carried off with the water, the quantity depending on the steepness of the grade. If the terrace is level, practically all the soil remains on the field. From this it is seen that a terrace should have no more grade than is absolutely necessary, and wherever conditions will permit it should be level. The level terrace is particularly adapted to land composed of deep, porous soils.

The level terrace is built in the same manner and to the same dimensions as the Mangum terrace, except that it has no grade to carry off the water. The rain that falls between the terraces is collected and held above the lower terrace until it evaporates, is absorbed by the soil, or finds its way slowly to an outlet at the ends of the terrace. (Fig. 10.)

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[4] Where the soil is extremely susceptible to erosion so that washing is likely to occur between the terraces, the vertical distances given above should be decreased by one-half foot. On the other hand, if the soil contains considerable humus and is capable of absorbing a large part of the rainfall so that it is not easily eroded, the vertical distances may safely be increased one-half foot.

The ends of level terraces may be closed to prevent the escape of any of the surface water, or may be left open to allow the water to pass away slowly. If the soil in a field is capable of absorbing all of the rainfall so as to leave no water standing on the surface long enough to injure crops, the ends are closed; otherwise they are left open. Where the ends are closed the terraces should be built at least 18 inches high in regions of heavy rainfall. In Figure 11 is shown a plan of a terraced field where two of the upper terraces completely encircle the top of a hill, there being no way for the water to escape over the surface to a drainage outlet. These terraces have given complete satisfaction. This practice is very common and has proven successful in regions of light rainfall with permeable soils.

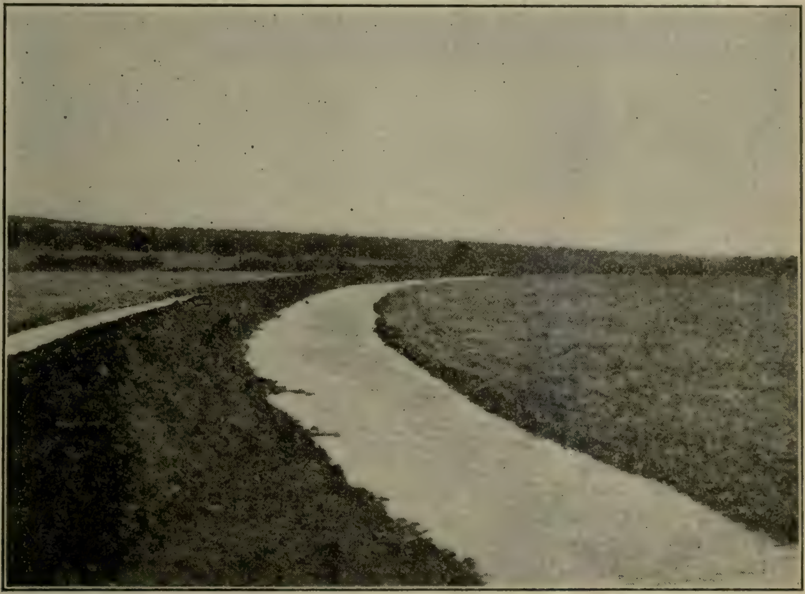

FIGURE 10.—Water standing above a circular level terrace with no outlet, after a heavy rain

The following tabulation gives the proper drops, or vertical distances between level terraces, for several kinds of soil in regions of comparatively heavy rainfall, it being assumed in each case that the soil is deeply plowed, contains considerable humus, and is capable of absorbing a large part of the rainfall.

Type of soil	Vertical distance, or drop, between terraces[6]
Sandy	4½ feet
Sandy loam	3½ feet
Clay loam	2½ feet
Clay	2 feet

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[6] For land slopes greater than 10 feet in 100 feet, the drop between terraces should be increased one-half foot.

In crossing a gully or draw in a field it is almost impossible to prevent the formation of pockets above the terrace that tend to hold the water on the surface. To remove the water that stands in such pockets it is recommended that tile be laid down the middle of the draw to a drainage outlet at the foot of the slope. A profile view of a tile line laid in a draw and provided with a drop inlet above each terrace is shown in Figure 12. The use of the drop inlets allows particles of soil in the water to settle before the water is drained away.

In regions of light rainfall, or where crops suffer severely from drought, level terraces are especially effective in retaining a supply of moisture which is often much needed on rolling and hilly lands during the growing season and during periods of drought. The following tabulation gives recommended vertical distances between terraces for different slopes in regions of light rainfall, this distance being governed largely by the horizontal distance between terraces required to obtain the best distribution of moisture.

Slope of land per 100 feet	Vertical distance, or drop, between terraces
Less than ½ foot	½ foot.
Less than 2 feet	1 foot.
Less than 4 feet	2 feet.
Less than 8 feet	3 feet.
Less than 12 feet	4 feet.

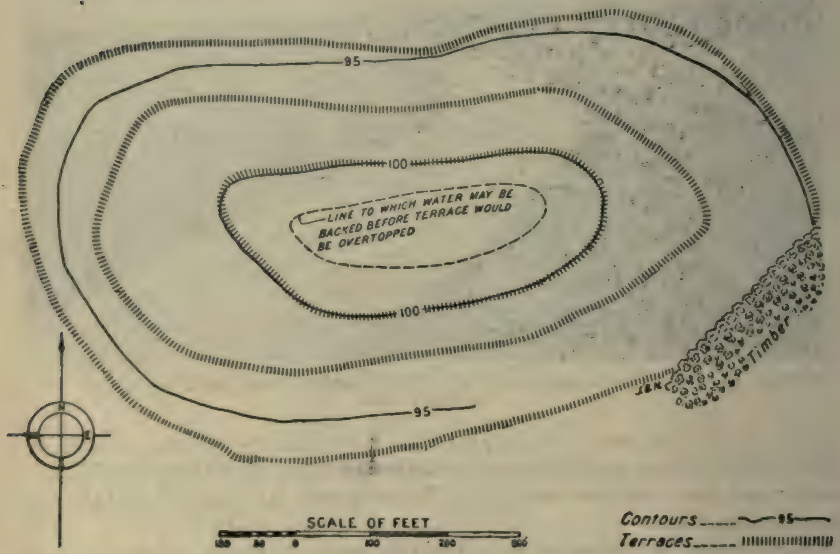

FIGURE 11.—An example of level terraces encircling the top of a knoll. The upper two terraces have no outlet

COMBINED SYSTEM OF LEVEL TERRACES AND TILE DRAINS

Some farmers who fully realize the importance and value of completely checking erosion on their farms have gone to the expense of installing complete systems of tile drains in connection with systems of level terraces. This unquestionably is the most effective method known to hold in place the soil of a hill farm, and its value can not be overemphasized. In a combined terrace and tile-drain system the lateral tile drains are laid in the depressions along the upper sides of the terraces and connect with the main tile drains that are generally laid down the center of gullies or draws to a drainage outlet at the foot of the slope. If the surface water does not pass rapidly through the soil to the tile drain it may be necessary to build surface inlets at intervals in the lateral tile lines to afford a direct flow of water into the tile.

It is advisable to employ the services of a competent and experienced engineer to design and superintend the construction of tile drains. Information relating to the proper design and construction of tile systems is given in Farmers' Bulletin 1606, Farm Drainage.

TERRACE OUTLETS

The provision of suitable outlets for the removal of surface water at the ends of graded terraces is often the biggest problem in terracing work. Natural watercourses make ideal outlets. However, they are not always available because the disposal of the water is generally limited to the field that is being terraced. To make the best use of natural drainage outlets, it is often advisable for neighboring farmers to cooperate in terracing adjoining fields. Where this is done, the terraces can be run across the property lines, and there will be no cause for the development of gullies at such lines as is often the case when it is necessary to end the terraces there.

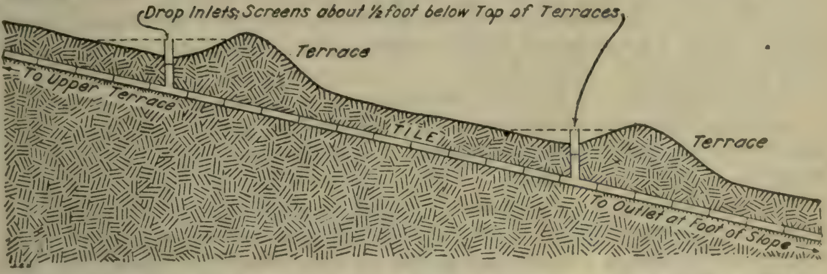
Drop Inlets; Screens about ½ foot below Top of Terraces
Terrace
To Upper Terrace
TILE
Terrace
To Outlet at Foot of Slope

FIGURE 12.—Method of removing water standing above terraces in a gully or draw

Side ditches along farm roads are often used for terrace outlets. Where they are not protected in some way, bad washing may occur and cause considerable injury to the road. When it is desired to use the side ditches along a public highway as an outlet for water from terraces, the officials in charge of the highway should be consulted before any work is done, so that possible injury to highways may be avoided. Washing may be prevented by building dams of brush, rock, or concrete across the ditches at suitable intervals down the slope, or by lining the ditches with some hard material such as stone or concrete. Usually, where a terrace discharges into a roadside ditch a considerable drop of the water occurs at the end of the terrace. In such cases a gully invariably forms along the upper side of the terrace. This can be prevented by building a concrete drop or by the use of a wooden-box trough which discharges the water with a free overfall into the ditch at the end of the terrace. Sometimes a protection for both the terrace channel and the ditch is built of concrete.

Erosion is most active near the end of a terrace, where the largest flow of water occurs. For this reason it is sometimes advisable not to cultivate the last 25 to 50 feet of the terrace and terrace channel but to seed them to grass for protection against erosion.

Sometimes it is found necessary to use a natural draw in a field as a terrace outlet. Where this is the case the draw should either be seeded to grass or some other means—such as the soil-saving dam—should be employed to prevent the erosion of a deep gully. Farmers' Bulletin 1234, Gullies: How to Control and Reclaim Them, contains descriptions of soil-saving dams.

LAYING OFF TERRACES

In laying off a system of terraces it is first necessary to provide for suitable outlets. Wherever possible, outlets should be placed at both ends of the terraces. This divides the water of the field and gives each terrace the minimum quantity to handle. Short terraces are less likely to break than long ones and are, therefore, more desirable.

When a draw or depression occurs near the middle of the field it is desirable to begin the terraces in the draw, so as to avoid building a high embankment such as would be required for carrying the water across it. Of course, the possibility of doing this depends upon the size of the draw. Sometimes it is found necessary to use such a draw as a terrace outlet where suitable outlets are not available at the border of the field.

It is always best to lay out the uppermost terrace first. A starting or reference point for this terrace should first be fixed by measuring down the proper vertical distance from the top of the hill or the highest point in the field. If a terrace midway down the slope is laid out first, and a point from which to start is selected at random without respect to the top of the hill, the chances are that the upper terrace will drain either too large or too small an area. If it is made to drain too large an area—which is a very common mistake in terracing—the excessively large volume of drainage water generally breaks the upper terrace, and usually all of the terraces below are then broken in turn. If the upper part of a hill belongs to a neighbor an effort should be made to induce him to terrace it. Otherwise it will be necessary to dig a hillside ditch or an embankment along the upper side of the field to intercept the water draining from the neighboring farm above.

Homemade instruments are often used for laying off the terrace lines—such as the A frame with plumb bob or spirit level—but unless the work is done very carefully the results are generally poor. A farm level, costing about $20, is widely used, and any intelligent person with care can obtain good results with this instrument.

The field work required in laying off a system of Mangum terraces with variable grade is as follows: Set the leveling instrument about midway between the ends of the uppermost terrace, and high enough so that when it is level the line of sight will be above the highest point in the field. Have an assistant hold a level rod on this highest point and read the rod there and also at a point 50 feet directly down the slope. Twice the difference between the rod readings obtained is the slope of the land in 100 feet between those two points. From the tabulation on page 8 find the recommended vertical distance, or drop, between terraces for that slope.

Example

Rod reading at top of field	1 foot
Rod reading 50 feet down the slope	5 feet
Difference in rod readings	4 feet
Twice the difference in rod readings or slope of land in 100 feet	8 feet

According to the tabulation (p. 8) the vertical distance, or drop, between the top of the field and the first terrace in this case should be 4 feet.

Set the target on the rod at 5 feet (which is 4 feet above the rod reading at the top of the hill). Have the rodman move the rod down the hill until the line of sight through the telescope strikes the center of the target. The point thus located is 4 feet below the top and therefore is the starting point on the first terrace, provided an outlet is available at each end.

From this point locate the line of the terrace in both directions, giving it the grade shown in the tabulation on page 8. To do this, the rodman sets the target at 5 feet, one-fourth inch (in the example above), moves 50 feet along the side of the hill, and is directed up or down the slope by the man at the instrument until the line of sight through the instrument strikes the center of the target. The point on which the rod rests is one-fourth inch lower than the starting point and therefore is the second point on the terrace. The target is then moved up another one-fourth inch, the rod carried on 50 feet farther and the third point located in the same manner. In accordance with the tabulation (p. 7), after the first 300 feet of terrace has been located the target should be raised one-half inch (instead of one-fourth inch) for each 50 feet; after 600 feet, 1 inch; after 900 feet, 2 inches; and after 1,200 feet, 3 inches, to the end of the terrace. A terrace should not carry water more than 1,500 feet in one direction if it can be avoided. If a longer terrace is necessary the grade should not be increased above 3 inches in 50 feet, but instead the lower end of the terrace should be built to extra height to take care of the excess water.

After the uppermost terrace has been located from the middle of the field toward one outlet, the next step is to locate the other half of this terrace in exactly the same manner.

Sometimes it is impossible to provide an outlet at each end of a terrace; it is then necessary to carry all the water to an outlet at one end. Under such conditions the terrace should not exceed 1,500 feet in length unless the lower end is given an extra height as before mentioned. In the above example the rod reading on the first point located on the terrace line was 5 feet. Use this as a reference point although it may not prove to be exactly on the terrace line because in this case locating starts at the edge of the field. Lower the target 6 inches and have the rodman carry the rod to the edge of the field at the upper end of the proposed terrace and move it up or down the slope until the line of sight through the instrument strikes the center of the target on the rod. This is the starting point for the terrace and is 6 inches higher than the reference point. The purpose of starting the terrace 6 inches higher than the reference point in the middle of the field is to insure that the terrace line shall pass close to the reference point in the middle of the field. It is evident—since the terrace line continually falls—that if it were started at the same elevation as that of the reference point, the line would fall below the reference point by the time the middle of the field is reached. The terrace can now be laid off by raising the target each 50 feet exactly as described in the previous example.

Before starting to locate the second terrace, the slope of the land should again be measured. Read the rod at a point on the first terrace about midway between its ends. Measure 50 feet directly down the slope and read the rod at this point. It will sometimes be necessary to reset the instrument farther down the hill before this can be done. If the instrument is moved, both readings must be taken from the new position. Having determined the slope of the land, refer again to the tabulation on page 8 to find the proper vertical drop between the terraces for the new slope and proceed in the same manner as with the first terrace.

The level terrace is much simpler to lay off than the Mangum terrace because—since it has no grade—it is not necessary to measure distances along the terrace line. The reference point should be located, as in the case of the Mangum terrace, and the terrace line run in both directions through this point. The rod reading will be the same for all points on the terrace as long as it is not necessary to shift the instrument.

In terracing work distances are measured by pacing. In pacing the distances the rodman should try to estimate as nearly as possible where the next point will be, and when directed up or down the hill by the levelman should keep the proper distance from the last point. To avoid mistakes the rodman should always change the target before starting to pace off the distance. If the field has been cultivated in ridges, the points should be located by setting the rod either always on top of the ridges or always in the depressions between them. If after the proper distance between points on the terrace line has been determined it is found that the rod is too low when set in a depression between the ridges and too high when set in the next depression above, then the proper location for the line of the terrace lies between the two positions of the rod.

A man should accompany the rodman and set stakes at points on the proposed terrace lines. A plowman should follow immediately and lay out the first furrow. Care should be taken to see that no abrupt turns are made with the plow. All changes in direction should be made by smooth, regular curves. Where gullies or draws are crossed, stakes should be set on each side and the terrace run directly across.

Long sights with the level (exceeding 500 or 600 feet) should be avoided. Much more accurate results are obtained where short sights are taken. When it becomes necessary to move the level so as to avoid taking long sights or in order to see around a hill, the rodman should remain holding his rod exactly on the last point located. When the level is set up at the new position the rodman raises or lowers the target so that the new line of sight of the level passes through the center of the target and the work proceeds as already described.

BUILDING TERRACES

In terracing a field, the uppermost terrace should always be built first. If a lower terrace is built first and there is not time to build the upper one before a rain comes, the lower terrace is almost sure to be broken and badly washed by the large volume of water drained from all the land above.

Implements most widely used in the construction of terraces are the wooden V drag (fig. 13), the V-shaped ditcher (fig. 14), the single-blade ditcher or terracer (figs. 15 and 16), and the ordinary road grader. Terraces are also built with an ordinary plow or with a plow having a specially designed moldboard. The ordinary disk plow and the 1-way plow are also sometimes used in the construction of terraces.

The wing on the steel ditcher shown in Figure 14 is adjustable so that the dirt can be moved laterally different distances from the point of the machine, and an extension can be placed on this wing, as shown in the figure, which makes it possible to move the dirt still further.

The machine shown in Figure 15 has an adjustable blade operating somewhat on the principle of the ordinary road grader. The blade is held in position by revolving steel disks located near each end of the blade. Both the horizontal and the vertical angle of the blade can be adjusted by means of the two levers shown in the figure. In the machine shown in Figure 16, the steel disks which hold the blade in position are located close together, a short distance behind the blade.

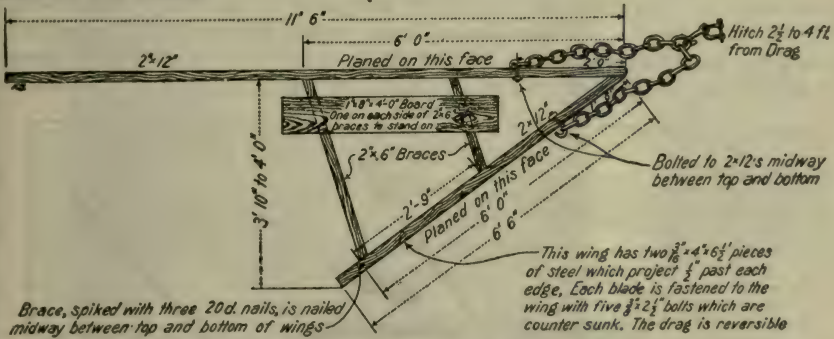
11' 6"
6' 0"
2"×12"
Planed on this face
2' 0"
Hitch 2½ to 4 ft. from Drag
1"×8"×4'-0" Board One on each side of 2"×6" braces to stand on
2"×12"
2"×6" Braces
Bolted to 2×12's midway between top and bottom
3' 10" to 4' 0"
2'-9"
Planed on this face
6' 0"
6' 6"
This wing has two 3/16"×4"×6½' pieces of steel which project ½" past each edge. Each blade is fastened to the wing with five ⅜"×2½" bolts which are counter sunk. The drag is reversible
Brace, spiked with three 20d. nails, is nailed midway between top and bottom of wings

FIGURE 13.—Homemade wooden V drag widely used for building terraces

Different sizes of the steel terracing machines described are built by the manufacturers. Four horses generally furnish sufficient power to operate the smallest machines having the shortest blades or wings, and six to eight horses the larger machines, depending upon the nature and condition of the soil. Tractors are quite generally used with the larger machines. In addition to being adjustable both horizontally and vertically, the blade of the machine shown in Figure 16 can also be tilted forward or backward.

There are two general methods of building terraces. One method consists of moving all the dirt from the upper side, the other of moving the dirt from both sides. Each method has its advantages although the second method is most widely practiced. It does not require moving the dirt as far as does the first method and does not necessitate the reversing of the terracing implement at the ends of the terraces except where more dirt is moved from the upper than from the lower side. Moving all the dirt from the upper side has the advantage of making a larger channel above the terrace for the removal or storage of the run-off water. It is also easier to move the soil down than up the slope. However, this method has the disadvantage of hastening the movement of the soil down the slope.

In Figure 17 is shown an average cross section for a terrace built by moving the dirt from both sides. The most common method practiced by farmers in building terraces is to leave the earth shoulders, indicated by the dotted lines in the figure, to be smoothed down by farm operations. It is better, however, to cut back these shoulders as indicated and place the dirt on the terrace. Terraces may be built either wider or narrower than that shown in the cross section. The wider the terrace the greater is the cost, but with large machinery it is easier to cultivate the wide terrace, particularly when it is crossed at an angle.

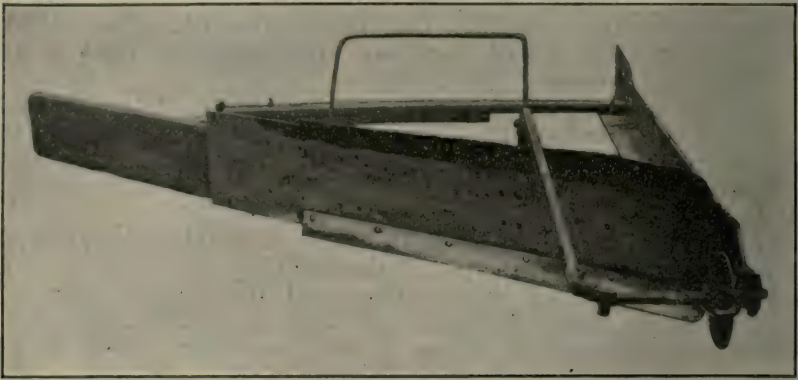

FIGURE 14.—V-shaped steel ditcher or terracer with extension board on movable wing

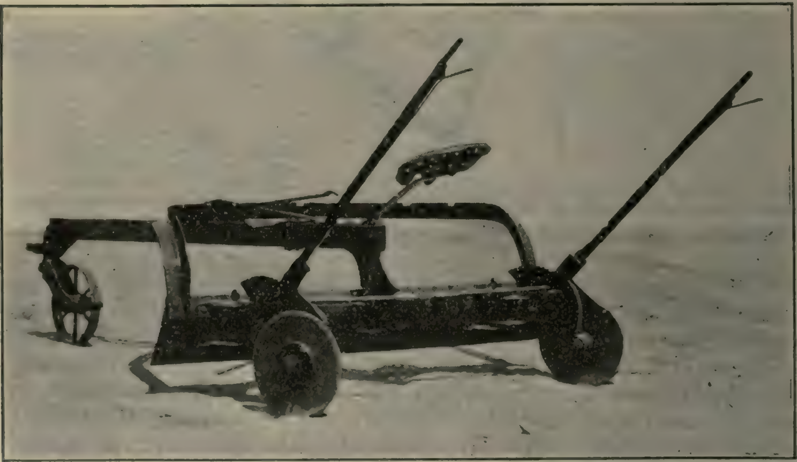

FIGURE 15.—A steel ditcher or terracer with steel revolving disks near each end of adjustable blade to hold blade in position

In building terraces with the V-shaped steel ditcher shown in Figure 14, where the dirt is moved from both sides, a backfurrow strip four furrows wide is first laid off with the plow. The terracing implement follows the second round with the plow, and it is generally advisable, under most soil and surface conditions encountered, to follow the plow each succeeding round with the terracer. The point of the machine is run in the plow furrow, the wing of the machine being set so as to move the dirt to the center of the terrace. As the terrace widens the wing of the machine is opened, and an extension is placed on it so that the dirt is placed as near the center of the terrace as possible. During the first few rounds the terrace should be built as high as possible. When there is not much vegetation on the ground and the soil is of uniform texture and easily worked, this machine is sometimes used without plowing except to lay out the terrace. If it is found that the terrace is not high enough or has not been built to the desired cross section, operations should be started at the center of the terrace and repeated for the full width of the terrace. The shoulder left where the last furrow is plowed should be beveled off and the dirt placed on the terrace embankment. Only one man is required to operate the V ditcher, but the best results are obtained when two men ride the implement and shift their weight as required for the most satisfactory operation. This machine operates quite successfully on rocky ground and in newly cleared ground.

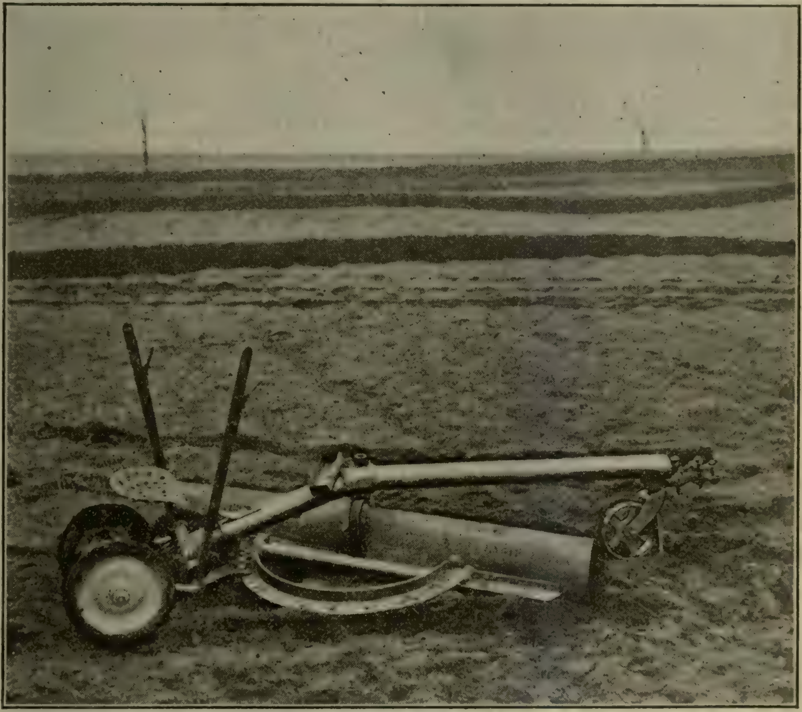

FIGURE 16.—A steel ditcher or terracer the blade of which can be tilted and is held in position by revolving disks a short distance behind the blade

In constructing terraces with the single-blade implement shown in Figures 15 and 16 different methods are employed. One is similar to the method above described, which consists of starting at the center of the terrace. Another is to start at the outside limits of the terrace and move the dirt to the center by repeated rounds, all vegetation that might interfere with the smooth operations of the implement being scraped to the center of the terrace with the first soil moved. Still another method, which is a compromise between these two, is to plow with the point of the implement parallel furrows 4 feet on each side of the center line of the terrace. (Fig. 18.) If sufficient dirt can not be plowed up in one trip to furnish a load for the machine, two plowing trips should be made before moving the dirt to the center of the terrace. The operation of plowing and then moving the dirt to the center of the terrace is repeated until the terrace is of the required width. In moving the dirt the blade is allowed to cut just enough into the firm ground to steady the implement and cause the blade to scour properly. In Figure 19 is shown one of these machines, which is plowing up dirt preparatory to moving it toward the center of the terrace on the next round. In Figure 20 the same machine is moving dirt to the center.

In building terraces with the wooden V drag the same method is employed as in using the V-shaped steel terracer. The only advantage of this drag over the steel terracer is its cheapness. In Figure 13 are given dimensions for the construction of a wooden V drag. Building terraces with this drag is a considerably slower process than with the steel terracer, and it is necessary to loosen up with a plow practically all of the dirt to be moved. The weight of two men is required on the wooden drag for its satisfactory operation.

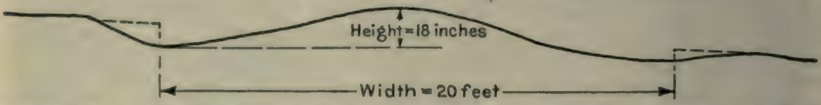

FIGURE 17.—Average cross section of a new terrace built by moving the dirt from both sides, showing the dimensions considered as the width and height of the terrace

In building terraces by moving all of the dirt from the upper side it is necessary to reverse the implement at each end of the terrace. All of the implements described above are reversible. The method of moving the dirt from the upper side is somewhat similar to that employed where the dirt is moved from both sides, but much of the dirt must be moved over the top of the terrace to form the proper slope on the lower side.

Terraces are sometimes built with a plow and Fresno scraper, particularly on steep slopes. A strip of ground is backfurrowed with a plow, and the loose earth on the upper half of the strip is moved over on the lower half. This process is repeated until the terrace is built to the desired height and cross section.

To finish a terrace properly some work with the scraper is generally required. The top of the terrace should be tested with the level and rod to see that it conforms to the proper grade. Any low places detected should be filled with the shovel or scraper. All large embankments across draws and gullies should be built with the scraper, and it is necessary to build such embankments considerably higher than the rest of the terrace to allow for settlement. Most breaks in terrace systems occur at crossings of gullies or draws, and it is therefore very important that a high, broad, substantial embankment be built across these places.

Any obstructions—such as rocks, stones, and stumps—that lie along the line of the terrace should be removed, since their presence might permit seepage and result in the failure of the terrace. In some parts of Texas the fields contain numerous large earth mounds generally known as gas mounds. These cause considerable difficulty

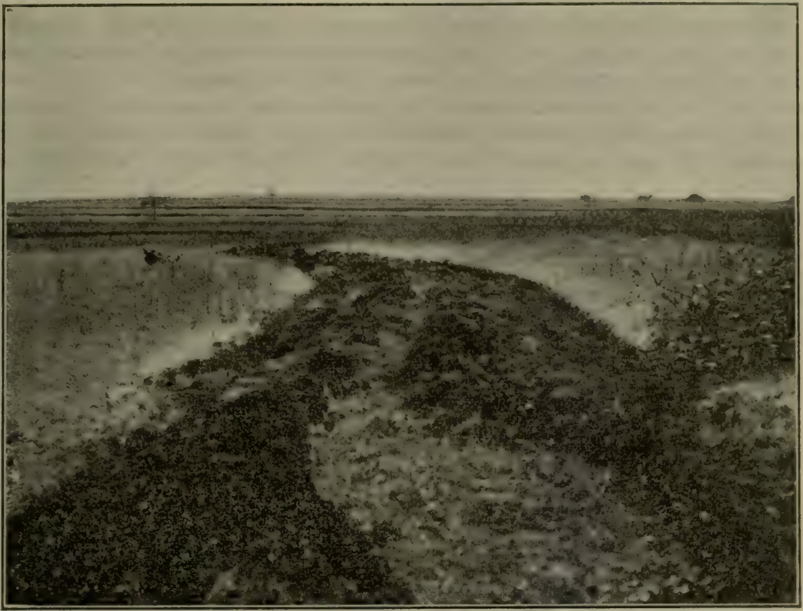

FIGURE 18.—One method of starting the construction of a terrace with the single-blade terracing machine shown in Figure 15. One round with the machine has been made, the furrows being about 8 feet apart

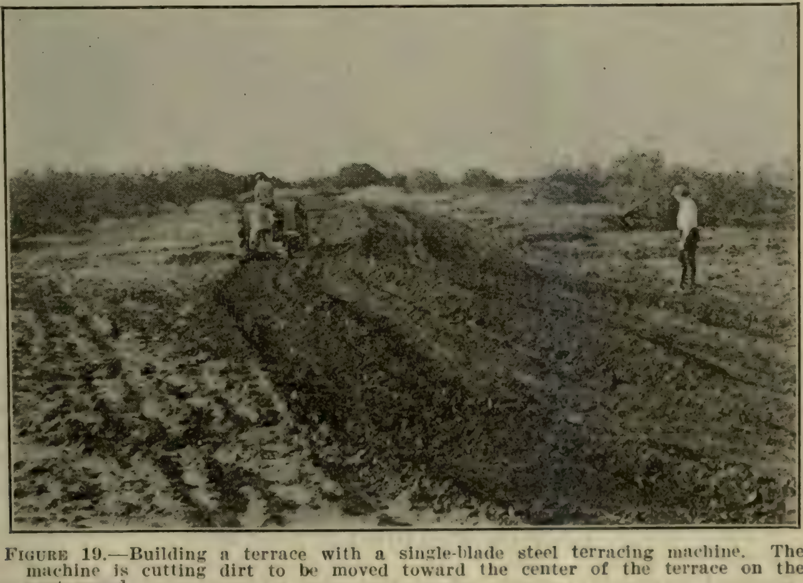

FIGURE 19.—Building a terrace with a single-blade steel terracing machine. The machine is cutting dirt to be moved toward the center of the terrace on the next round

in terracing fields. Where they lie along the lines of graded terraces it becomes necessary to provide passageways through them by means of the plow and scraper.

Where terraces are continued from one field to another across a fence row it is necessary to build the sections near the fence by hand labor, using the spade and shovel. It is very important that such parts of the terrace and channel be built of the same size as the rest, and considerable attention should be given later to see that the waterway is kept open so that the free flow of water shall not be obstructed.

POORLY BUILT TERRACES WORSE THAN NONE

The directions for laying off and constructing terraces should be followed carefully, and after the terraces are built they should be checked with a level to make certain that they have the proper grades and that there are no low places in them. Poorly constructed terraces with improper grades are almost certain to fail and are likely to cause more serious erosion than would have occurred without terraces. The old maxim, "what is worth doing at all is worth doing well," is especially applicable to terracing work. If one has not time to terrace all of a field properly it is far better to terrace the upper part well than to attempt to terrace the whole field and do a hurried and poor job.

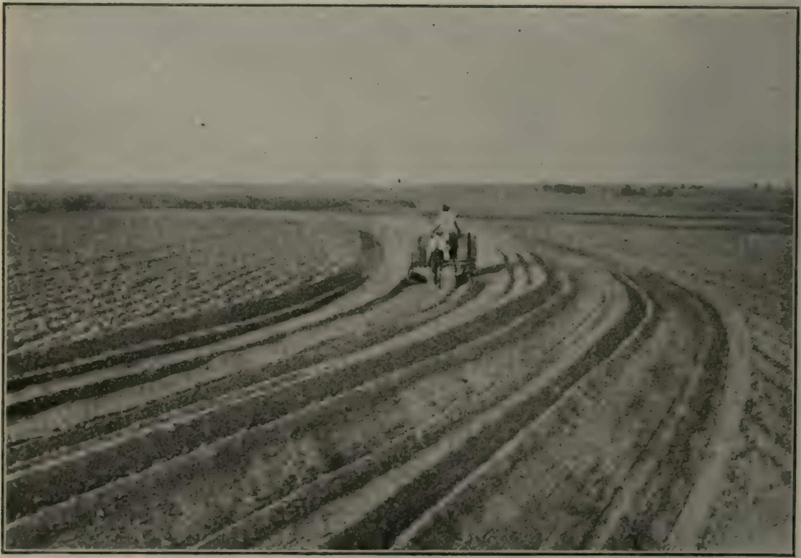

FIGURE 20.—Building a terrace with a single-blade terracing machine. The machine is moving dirt toward the center of the terrace

COST OF BUILDING TERRACES

Several variable factors affect the cost of constructing terraces. Some of these are, nature and condition of the soil, length of the terraces, vegetal covering, kinds of implements used, methods employed, and the skill and experience of the operator and the vigor with which he pushes the work. In some instances constructing terraces in wet soil may easily cost twice as much as in dry soil. More time and labor are required to build a terrace in a heavy clay than in a sandy loam soil. Short terraces cost more per running foot than long terraces, owing to the time lost in more frequently turning the equipment at the ends. A heavy covering of long grass or weeds usually interferes with terrace building and retards the progress of the work. Roots, rocks, sprouts, and stumps add materially to the difficulty of construction and in many cases make the cost of terracing prohibitive. The costs of constructing the same terraces by two experienced operators might easily vary as much as 50 per cent because of differences in skill. Farmers ordinarily do not have sufficient terracing work to do on their own farms to make them proficient in this work, and until an operator gains sufficient experience the cost of constructing terraces is appreciably greater than that for which he might do the same work later. To these several factors and to the fact that very little reliable cost data have been collected may be attributed the great differences of opinion among farmers and engineers with regard to the cost of terracing.

Where conditions are ideal for terracing work as regards type and condition of soil, uniformity of slope, freedom from stumps, roots and rocks, and absence of gullies or depressions so that no scraper work is required, a terrace 15 inches high, 20 feet wide, and not less than 1,000 feet long can be built on slopes of up to 6 or 8 feet in 100 feet at a cost of about $20 per mile or $1.50 per acre. The cost will range from the foregoing to as high as $180 per mile or $15 per acre where a field is badly cut up with many deep gullies. Table 1 may be taken as a general guide to the cost of building terraces of the dimensions given above, in light soils. For heavy soils, about 50 cents per acre should be added to the costs given in the table. The cost per acre will also increase on steeper land and for shorter terraces. Variations from the above costs will also occur on account of inexperience, poor equipment, and wet soil.

TABLE 1.—*Approximate costs*[1] *of constructing terraces 15 inches high, 20 feet wide, and not less than 1,000 feet long, in light soils on moderate land slopes*

Description of land	Cost per acre	Remarks
Clean-cultivated land, no gullies	$1.50–$2.50	
Grass or virgin land, no gullies	2.00– 3.00	
Clean-cultivated land, small shallow gullies	3.00– 6.00	Depending upon the number of gullies.
Clean-cultivated land, gullies 3 to 6 feet deep	7.00–15.00	Do.
Newly cleared land, no gullies, most stumps grubbed out.	7.00–12.00	Depending upon the kind and number of roots and stumps.

[1] The costs given above are based upon the use of a steel ditcher or terracer of the V shape or grader type. In using a wooden V drag the number of trips required to build a terrace to a given width and height is greater than that necessary with a steel ditcher or terracer, the time required amounting to from one-fourth to one-half more. Where the labor and power are paid for in cash the terraces thus constructed cost from 25 to 40 per cent more than when constructed with the steel terracer depending, of course, upon the soil conditions. Cost records also show that terraces built with a road grader in the hands of an experienced operator cost about 25 per cent less than when constructed with the steel terracer.

The costs of terracing work given are based upon the usual costs of labor and of team and tractor power. Frequently during seasons of the year when farm work is slack, labor and teams that would otherwise be idle can be employed to advantage on terracing work. By doing the work at such times and using a homemade V-drag, the cash outlay required is small. Under such conditions, lack of funds is a poor excuse for failure to protect land against erosion.

CARE AND CULTIVATION OF TERRACES

Terraces require considerable care and attention, especially during the first year before the loose soil has had time to become thoroughly settled. All apparently weak places should be visited after every heavy rain, and any breaks that occur should be repaired immediately. It is best not to cultivate the terraces the first year, but to seed them to some kind of cover crop.

On steep slopes it is advisable to run the crop rows parallel with the terraces, one row being on the top of the terrace if a single-row cultivator is used. The cultivation of the top row tends to keep the top of the terrace at the proper height. Where a 2-row cultivator is used it is better to run rows on each side of the top of the terrace, since with that implement it is difficult to cultivate a row on the top. Where the rows are run across the terraces—as is done commonly on moderate slopes, particularly where large farm machinery is used—the terraces tend to flatten out when cultivated, and more maintenance work is required than is the case where the rows are run parallel with the terraces.

All terraces that are cultivated should be plowed at least once a year, and the soil should be thrown to the center. In this way the height of the terrace is maintained and the base broadened each year. Some washing is bound to occur between terraces which tends to fill up the terrace channel. This deposit should be moved on to the terrace embankment.

Steep land that washes badly between the terraces should not be cultivated. The terraces should first be well built and then the entire field seeded to grass and used for pasture or meadow.

When it is necessary for terraces to cross a farm road they should be constructed without regard to the road. Where the terraces are as much as 20 feet wide, no provision need be made for passing traffic across them, but they should be carefully maintained to prevent possible breaks. With narrower terraces, considerable inconvenience to traffic and injury to the terraces generally result where no provision for crossing is made. Sometimes the water is carried under the roadway through culverts. The principal objection to this is that the capacity of the waterway is thus greatly reduced, and the free flow of water through the culverts is often obstructed by stalks or other trash washed from the field. A wooden bridge spanning the channel so as not to reduce greatly the cross-sectional area of the waterway, makes a more desirable and satisfactory crossing.

Following the terracing of eroded or run-down land it is generally advisable to improve the soil for at least one year by the use of cover and green-manure crops to be plowed under, rather than to attempt to grow a money crop on it immediately. The choice of crops for this purpose will depend upon locality, but for summer crops soybeans, cowpeas, and velvetbeans are among those of first consideration. As a winter cover crop to bind the soil and to add organic matter there is perhaps nothing that will equal rye and vetch. Manure, where available, should be used, especially on thin spots.

U. S. GOVERNMENT PRINTING OFFICE: 1931

For sale by the Superintendent of Documents, Washington, D. C. - - - - Price 5 cents

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1670

HYDROCYANIC ACID GAS AS A FUMIGANT

FOR DESTROYING HOUSEHOLD INSECTS

1862 1889

FUMIGATION with hydrocyanic acid gas is one of the most effective methods of destroying household insects. It is equally suitable for use in ordinary dwellings, in apartment houses, and institutional buildings such as hospitals, and in loosely constructed temporary or portable structures. This gas is, however, extremely poisonous to human beings, and should not be used without knowledge of the dangers involved and of the precautions to be taken.

There are several methods of generating and applying hydrocyanic acid gas in fumigation. The pot method, which consists of placing sodium cyanide in a mixture of sulphuric acid and water in an earthenware crock or a barrel, is the safest method for the inexperienced householder who wishes to fumigate a few rooms or a small house. The other methods involve exposure of various forms of calcium cyanide or liquid hydrocyanic acid, either pure or combined with some absorbent material, and should be used only by an experienced fumigator.

The details of these methods and the precautions to be taken are described in this bulletin. By carefully following these instructions any intelligent person can safely use hydrocyanic acid gas and obtain excellent results.

This bulletin supersedes Farmers' Bulletin 699, Hydrocyanic Acid Gas Against Household Insects.

Washington, D. C. Issued April, 1932

HYDROCYANIC ACID GAS AS A FUMIGANT FOR DESTROYING HOUSEHOLD INSECTS

By E. A. Back, *Principal Entomologist, in charge*, and R. T. Cotton, *Senior Entomologist, Division of Stored Product Insects, Bureau of Entomology*

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WHY HYDROCYANIC ACID GAS IS A GOOD FUMIGANT

HYDROCYANIC ACID GAS is one of the most effective, useful, and popular fumigants known for destroying insects in structures occupied by man. When breathed in concentrated form it is deadly to human beings as well as to insects, but with proper precautions can safely be used in fumigating not only ordinary homes, but apartment houses (fig. 1), detached hospital and institutional buildings (fig. 19), and portable structures such as convicts' bunk wagons (fig. 2), automobile trailers, and Pullman cars. It is frequently used to destroy clothes moths and carpet beetles in the finest dwellings. (Fig. 5.)

Hydrocyanic acid gas combines good features possessed by no other fumigant. It can be used without fear of fire or explosion, without dismantling or disarranging the house furnishings, and with harmful effects upon few of them. Its cost is small; it can be removed from the buildings in a very short time; and it kills so quickly that it can be used in houses so poorly constructed that other fumigants escape before they have had time to become effective. (Fig. 3.) Being lighter than air, hydrocyanic acid gas escapes upward when windows and doors are opened, or through cracks in buildings, and does not settle to form a dangerous blanket of vapor upon sidewalks or roadways. Modern buildings of concrete and brick are extremely tight and such gas as escapes does so slowly and is dissipated upward and away from completely detached buildings.

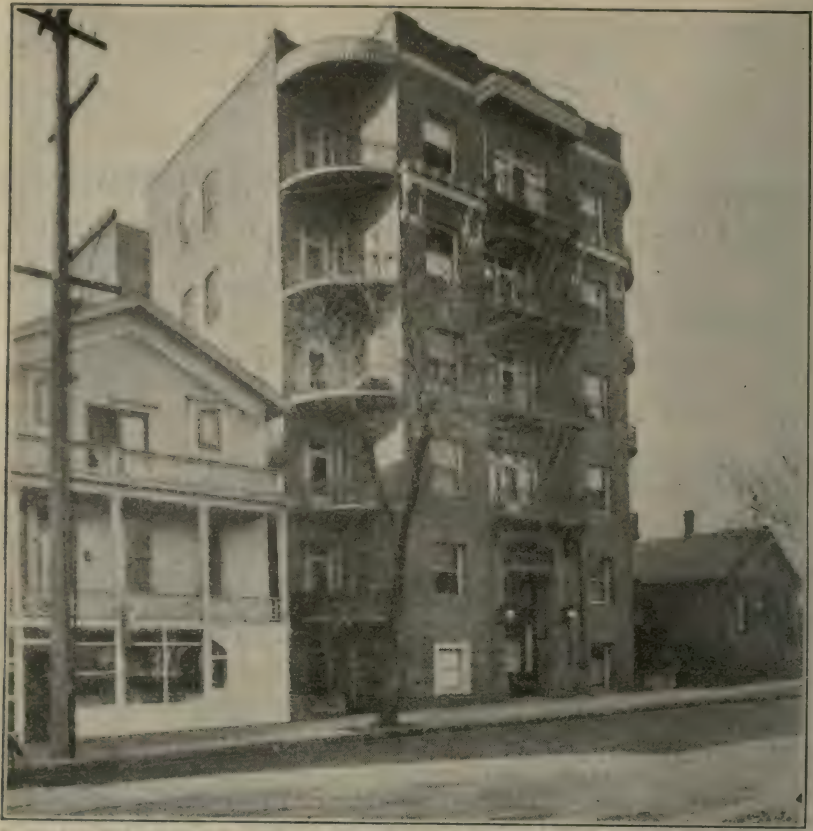

FIGURE 1.—Apartment house fumigated with hydrocyanic acid gas. Very few windows on sides. The frame buildings on either side of the apartment building, and separated from it by narrow alleys, were occupied during the entire period that the apartment house was being fumigated. A professional fumigator was on the ground all the time to make note of conditions

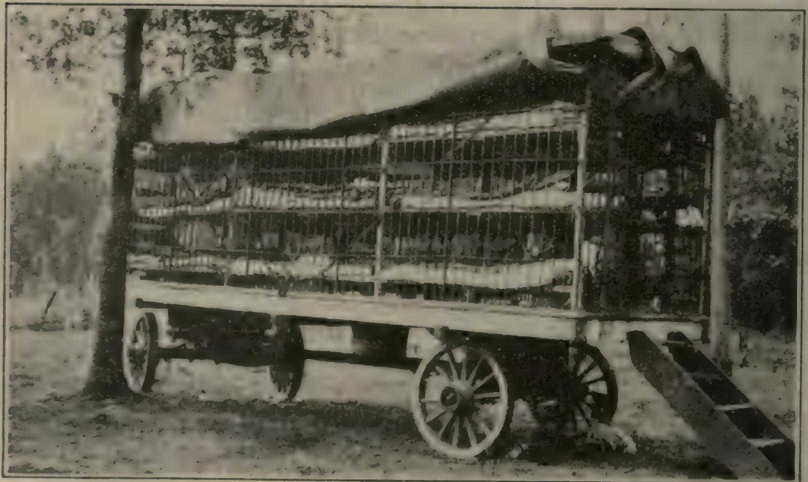

FIGURE 2.—A prison bunk wagon such as is used for convict labor. Vermin in the beds of such structures can easily be killed by covering the entire conveyance with tarpaulins and fumigating with hydrocyanic acid gas

DANGER IN THE USE OF HYDROCYANIC ACID GAS

Hydrocyanic acid gas is deadly to all animal life, including human beings. It should be used only by persons who have thoroughly acquainted themselves with the method of using it and with the dangers involved. It is preferable for fumigations to be conducted by professional fumigators, but it is quite possible for a careful, well-informed person to use hydrocyanic acid gas with safety and with excellent results, particularly in fumigating only one or a few rooms. In the thousands of house fumigations which have been made, only a few deaths have occurred, and these have been the result of ignorance or of extreme negligence on the part of the persons conducting the fumigations, who failed to make certain that all persons were out of the buildings before generating the gas or to guard against the entry of those unaware that fumigation was in progress.

FIGURE 3.—A temporary mess hall and kitchen at a hospital were fumigated with hydrocyanic acid gas for four hours to control cockroaches. (For diagram of floor plan see fig. 9.) Persons passed at ordinary pace along the corridors surrounding this building without the least ill effect from escaping gas. There should, of course, be no loitering about the walls of buildings that are being fumigated

Hydrocyanic acid gas can cause death in a few minutes if it is breathed in concentrated form. From 5 to 10 breaths of the gas in the concentration used in house fumigation are sufficient to kill the average person. According to R. Kobert, a concentration of 120 to 150 parts of the gas per million parts of air is dangerous in from 30 to 60 minutes, while one of 3,000 parts per million is quickly fatal. In weak concentrations the gas is not acutely dangerous, but may cause dizziness, vomiting, or even loss of consciousness. When inhaled in concentrated form, it prevents oxidation in the tissues, so that, although breathing continues for a brief period, the oxygen can not be utilized and death from asphyxia soon results.

SAFEGUARDS IN THE USE OF HYDROCYANIC ACID GAS

Hydrocyanic acid gas must be handled with great care, not only for the safety of the operator, but for the safety of the general public. In most cities its use is regulated by the public health department, which forbids its use without a permit.

Before a building is fumigated, all persons except the operator must leave the premises and remain away until the work has been completed and the building properly ventilated. If one of several apartments in a building is to be treated, arrangements must be made for occupants of all apartments to vacate during the fumigation period. In most cities it is unlawful to fumigate a semidetached or "row" house unless the occupants of the adjoining house on each side also vacate. A building being fumigated should have all entrances locked and signs prominently displayed to warn persons approaching the building that it is being fumigated with a deadly gas. In addition, one or more guards should be stationed to keep persons from loitering on sidewalks and from attempting to enter the building.

Guards, grossly neglecting their duties for even a few minutes, have been responsible for fatal attempts to enter buildings under fumigation.

VACATING ADJOINING APARTMENTS AND BUILDINGS

The common insect pests of dwellings spread so easily from one apartment to another in an apartment house, that cooperation in vacating all apartments for several hours during the daytime to permit intelligent fumigation of one or more apartments, if not the entire building, would be to the tremendous advantage and peace of mind of all occupants. Whatever is done to kill insects in one apartment is to the advantage, and for the protection, of all others in the same building.

It is often feasible to fumigate a well-constructed "row" house while the adjoining houses are still occupied, but this should never be attempted unless the occupants of the adjoining houses agree in advance to keep their houses open for frequent inspection by the professional fumigator and to be in readiness to vacate on a minute's notice should the gas be found to be leaking through the party walls. Special care should be taken to see that there are no cracks in party walls and no underground or basement connections of any sort along which the gas can escape from the house under fumigation. Sometimes, when the leakage of gas is great on account of loose construction, a breeze may blow enough of the diluted gas to near-by structures to make them dangerous. If this occurs, the fumigator should insist on shutting all windows facing the building under fumigation.

PREPARING A ROOM FOR FUMIGATION

In preparing a room for fumigation, all openings such as windows, fireplaces, hot-air registers, ventilators, and stovepipes should be closed and made as tight as possible with the aid of gummed or pasted strips of paper or by crowding wet newspapers or rags into cracks and crevices. Larger openings, such as fireplace flues, can conveniently be closed by crowding into them pillows previously wrapped with old papers or cloth. Windows should be wedged as tightly as possible even when sealed with paper. Closets, bureau drawers (fig. 4), trunks, boxes, and other containers should be opened to facilitate the penetration of the gas. The contents of tightly packed trunks may be hung on a line temporarily installed in the room. It is wise to drape blankets and other bedding over bedsteads, chairs, or open closet doors, and to raise mattresses a little from the springs. Carpets and rugs may be raised off the floor in places by resting them on chairs. Many living and dining rooms are fumigated with apparent success, however, without moving carpets except by turning them back about the edges wherever furniture will permit.

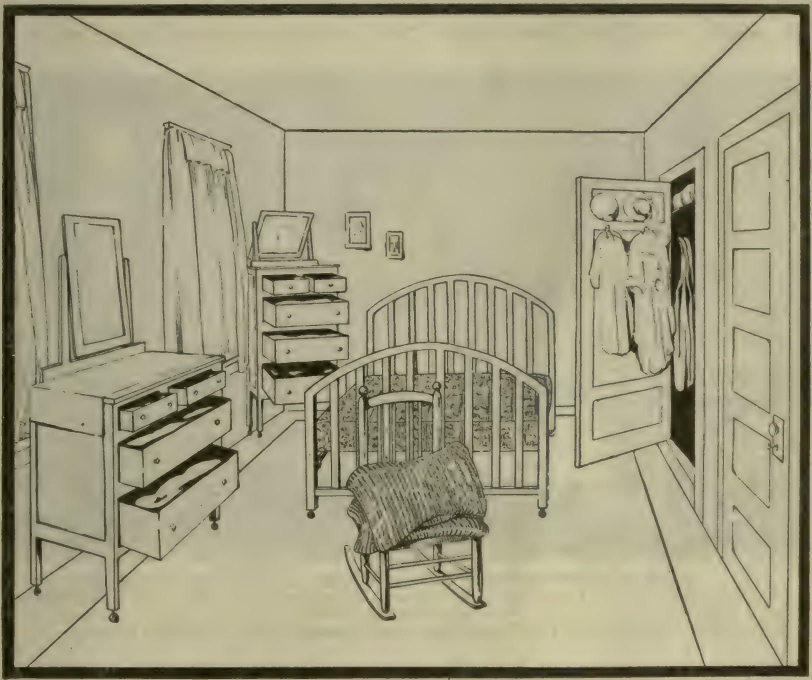

FIGURE 4.—Sketch of bedroom showing bureau and dresser drawers and closet door opened as they should be during a fumigation

Living plants, liquids, and moist foods should be removed before fumigation, and it is better to remove fine watches and small clocks, although larger clocks can remain. Fabrics, including tapestries and paintings, silverware, copper, brass, and gilt frames are not known to be affected. (Fig. 5.)

Unless the fumigator is equipped with a gas mask, it is best to arrange to ventilate the room or house by opening windows and doors from the outside. Usually the opening of the front and back doors on the ground floor and several windows on the ground and second floors of dwellings will result in a rapid ventilation. The ventilation of larger buildings requires special preparation in advance, if gas masks are not used.

METHODS OF GENERATING HYDROCYANIC ACID GAS

There are several methods of generating hydrocyanic acid gas, all of which are effective and available for household fumigation. Some can be used with safety by any intelligent person, even if inexperienced, while others should be used only by the experienced fumigator. The simplest and safest method for the householder wishing to fumigate a few rooms, or an entire small house, is the so-called "pot method," which consists of placing sodium cyanide in a mixture of sulphuric acid and water in a potlike container or generator. The other methods consist of exposing various forms of calcium cyanide or liquid hydrocyanic acid, either pure or combined with some absorbent material. Such methods should be used only by an expert fumigator, or by a person who has received personal instruction through demonstrations given by a professional. Simple as the procedure usually is, the operator must always proceed with great caution.

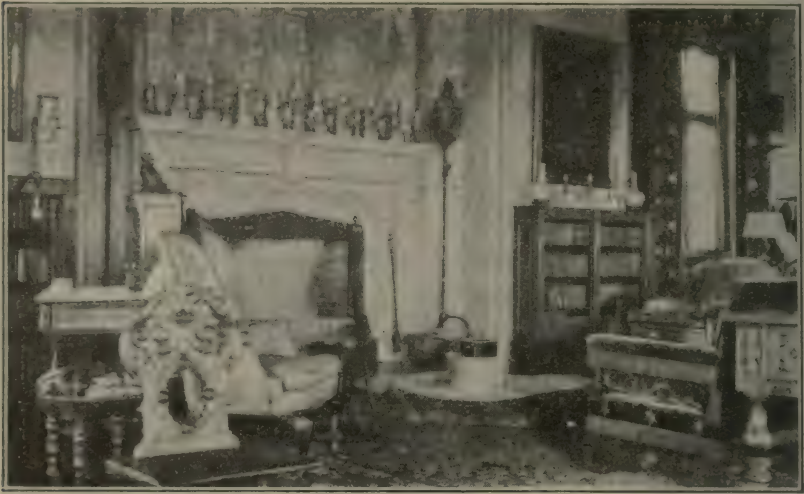

FIGURE 5.—Room in fine home under fumigation for the destruction of clothes moths and carpet beetles. Paintings, gilt frames, rare tapestries, fine rugs, and furnishings need not be removed. Note the crock placed near the fireplace. The rug has been laid back and plenty of newspapers have been used about the crock

THE POT METHOD

CHEMICALS REQUIRED

The pot method of generating hydrocyanic acid gas is so called because the chemicals used in the process are placed together in a pot or vessel of similar form. (Figs. 6 and 7.) The chemicals required are a good grade of sodium cyanide (96 to 98 per cent), a commercial grade of sulphuric acid (66° Baumé), and water.

Sodium cyanide, which has displaced potassium cyanide in present-day fumigations, is a white, crystalline substance that for fumigation purposes is prepared in egg-shaped lumps weighing approximately 1 ounce each. Sodium cyanide is a violent stomach poison and in addition may be absorbed through open cuts on the hands. It is best to handle it with gloved hands and to keep unused portions in glass containers to prevent spoilage. Small particles eaten by children or pets are sure to cause death. Sodium cyanide can be purchased in tin cans containing from 1 to 100 pounds or more. In 1-pound tins it sells for about 40 cents per pound; in 100-pound lots for 16 to 22 cents per pound. It is well to calculate the quantity needed, purchase a tin or tins containing an amount nearest that required, and use all of it, thus avoiding the necessity of caring for or disposing of left-over stock.

Pure sulphuric acid is a heavy, colorless liquid, but the commercial acid used in large-scale fumigation work is apt to be slightly discolored, or murky, owing to impurities. It is highly corrosive, and will cause injury if it spatters on the clothing or the body of the operator, or upon floors or rugs. It can be purchased in glass bottles for about 10 cents per pound (about one-half pint) or in carboys for about 4 cents per pound. For small-scale fumigations 8-pound bottles of acid are convenient.

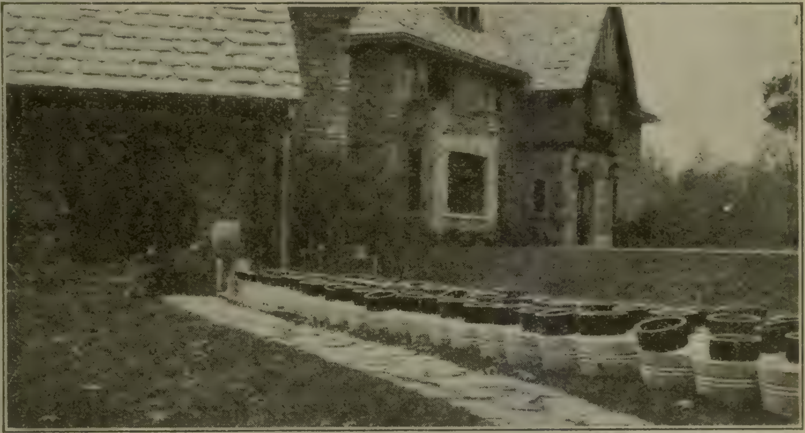

FIGURE 6.—Crocks used in fumigating a large modern dwelling by the pot method. Note the carboys of sulphuric acid, keg of sal soda, and the cans of sodium cyanide near the porch. All water and acid were added to the crocks outside the house and all cyanide was weighed and wrapped in the open air by gloved assistants

FORMULA

To obtain the best results the chemicals should be mixed according to the following formula:

Sodium cyanide (96 to 98 per cent), ounce by weight	1
Sulphuric acid (66° Baumé), fluid ounces	1½
Water, fluid ounces	3

Since there are 16 ounces in 1 pound and 32 fluid ounces in 1 quart, this formula requires 1½ pints of sulphuric acid and 1½ quarts of water for each pound of sodium cyanide. This is known as the 1–1½–3 formula and is more generally satisfactory than the 1–1½–2 formula, which may produce a little more gas but makes it more difficult to empty the jars after fumigation, because of the larger number of crystals in the residue.

PROPER ORDER OF PLACING CHEMICALS IN THE FUMIGATING JAR

To generate hydrocyanic acid gas by the pot method, the operator should first pour the water into the generator or crock and then add the acid. If the water is poured into the acid, the reaction is so violent that the operator may be dangerously burned by the spattering of the acid-water mixture. The addition of the sodium cyanide to the mixture of water and acid causes an immediate chemical reaction and hydrocyanic acid gas is given off. The fumigant, mixed with some steam produced by the violent chemical reaction, has the appearance of ordinary steam or light bluish smoke (fig. 7) and an odor resembling that of peach kernels. The pure gas is colorless.

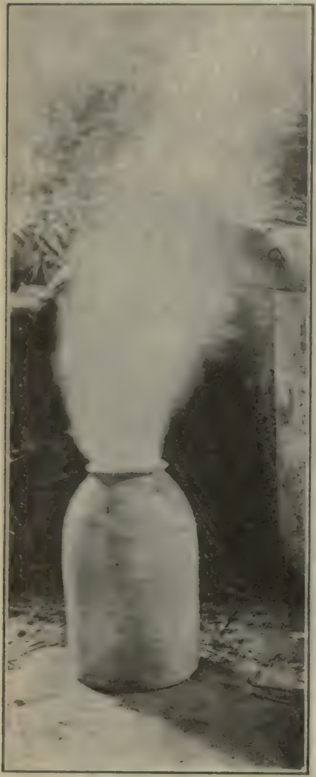

FIGURE 7.—The charge of cyanide has been lowered into the jar, and hydrocyanic acid gas and steam are rising in the first rapid evolution of the gas, which occurs as soon as the acid eats through the paper covering the cyanide. This type of jar is not recommended; the type shown in Figure 6 is preferable

DOSAGE

The dosage is computed on the basis of the amount of sodium cyanide required. For general fumigation work in a reasonably well constructed house 1 pound of sodium cyanide will produce enough gas to treat 1,000 cubic feet of space. If the house is loosely constructed or a very short exposure is given, from 1½ to 2 pounds of sodium cyanide may be needed.

HOW TO FIGURE THE QUANTITIES OF CHEMICALS NEEDED

In figuring the quantities of chemicals needed to fumigate a room at the rate of 1 pound of sodium cyanide per 1,000 cubic feet, the room should be measured and the cubic contents obtained by multiplying the length by the breadth by the height. For example, a room 10 feet wide, 20 feet long, and 10 feet high contains 2,000 cubic feet and requires 2 pounds of sodium cyanide, 3 pints of sulphuric acid, and 3 quarts of water.

TYPE OF GENERATOR

The best type of container or generator in which to mix the chemicals depends largely upon the size of the inclosure to be fumigated. If rooms of from 2,000 to 3,000 cubic feet are to be treated, a 4-gallon earthenware or stone crock will be suitable. For smaller rooms 2-gallon or 3-gallon crocks or even enameled wash basins will serve. If wash basins are used, the enamel should be clean and unscratched; otherwise the acid may eat through the metal and injure the floor.

For large houses a few large containers (figs. 8, 9, and 10) are sometimes preferable to many small ones. (Figs. 6 and 11.) In such cases 50-gallon wooden barrels can be used. They are large enough to handle safely a charge of 30 pounds of sodium cyanide, or sufficient material to fumigate 30,000 to 40,000 cubic feet of space. (Fig. 8.) Such barrels must be water-tight. They should be thoroughly scrubbed, both within and without, filled with water, and allowed to stand for at least 12 hours previous to their use. Ordinary oil or molasses barrels are usually satisfactory if all hoops are sound. Flour barrels are not heavy enough.

Before the chemicals are added, the barrels should be set in galvanized-iron washtubs (fig. 12) in each of which has previously been placed a pailful of water containing several handfuls of ordinary washing soda. This is a precaution against leaking of barrels and provides for catching and neutralizing any small quantities of the acid-water mixture that may work out of the barrel. Galvanized-iron tubs containing a similar soda solution should also be used, if possible, when crocks are used as generators.

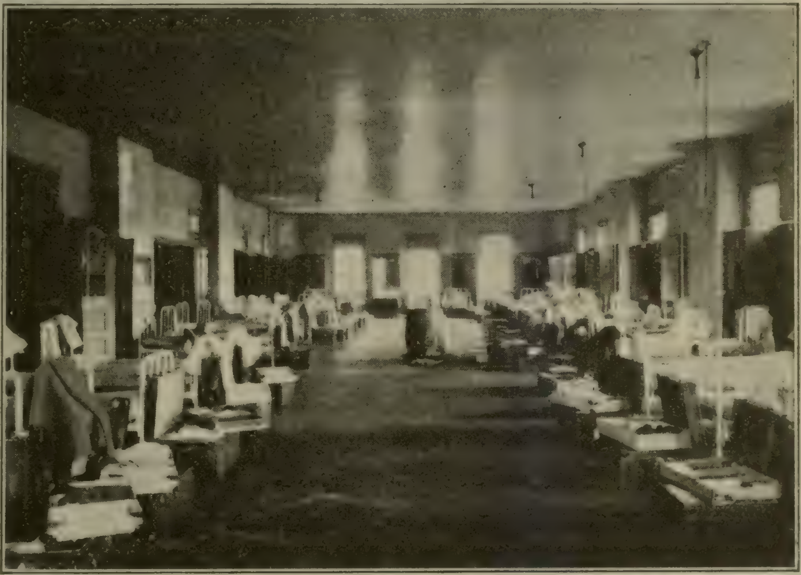

FIGURE 8.—A large dormitory room containing about 40,000 cubic feet of space in a tight brick building. A dosage of 32 pounds of sodium cyanide in the 50-gallon barrel shown satisfactorily stamped out a bedbug infestation. The barrel should have been placed in a galvanized-iron washtub. The old cloths used about the barrel would not have protected the floor had the barrel leaked. Note opened trunks

HOW TO GENERATE THE GAS

After the room or house to be fumigated has been prepared according to the directions on page 4, the generators should be distributed and the water and acid added. The acid should be added to the water slowly, since this operation produces heat, and a too-sudden change in temperature is likely to cause the crocks to crack. If the floors are highly polished and will be damaged by the heat from the jars, the jars may be set on bricks set in each tub. If crocks are used, the water and acid should be added outdoors (fig. 6) or in a room with a concrete or tile floor, and with drain close by so that the breaking of a crock will not result in an acid-burned floor.

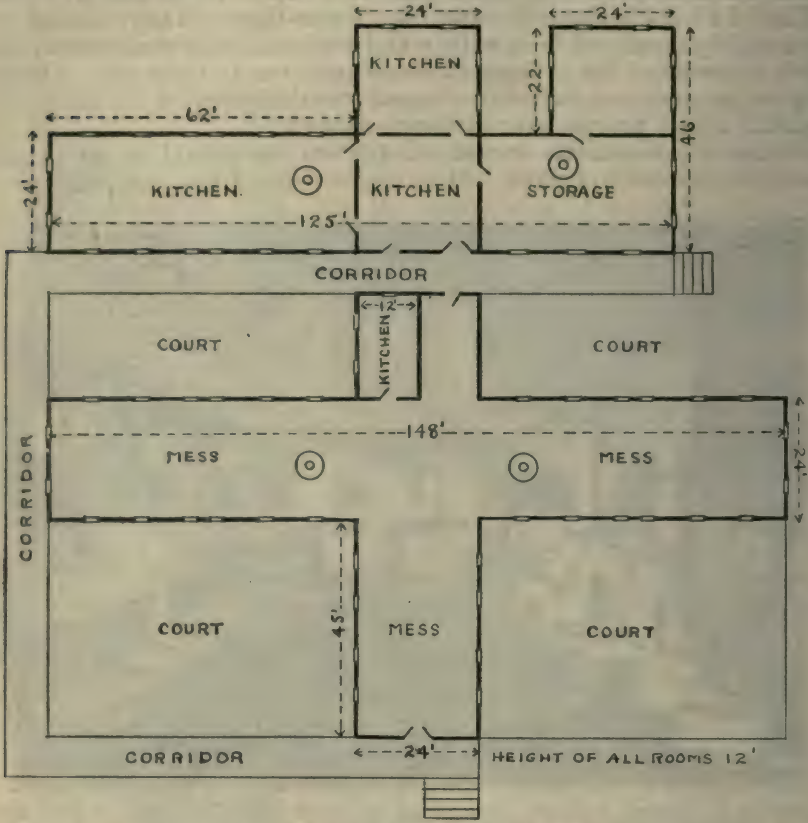

FIGURE 9.—Floor plan of mess hall and kitchen and storage of building (shown in fig. 3). The construction is temporary and very loose. Fumigation with hydrocyanic acid gas for 4 hours put an end to a serious cockroach problem without endangering occupants in near-by buildings. Barrels were used according to the pot method. The fires were left burning in the kitchen

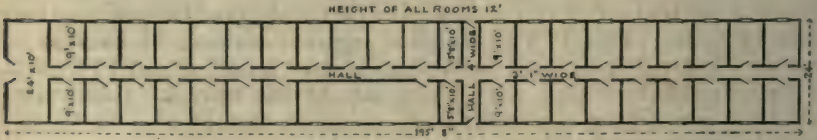

FIGURE 10.—Floor plan of nurses' quarters fumigated with hydrocyanic acid gas for bedbugs by placing two barrels in center of hall. Wind during the period of fumigation prevented concentrations on windward side sufficient to kill the insects. Results would have been better had crocks been placed in each room and the room doors kept shut

It is even more advisable to fill barrels outside if labor is plentiful and the charge for carrying them in is not too heavy.

The proper quantity of sodium cyanide, which should be weighed out beforehand, should be placed in a paper sack or small piece of newspaper, in a compact bundle, and set near the generator to which it belongs. If several generators are employed, the generation of the gas can be delayed by wrapping the cyanide in several thicknesses of paper or by using two paper bags of different size and placing the smaller inside the larger. The gas will not generate until the acid has eaten through the paper, so the operator will have a longer time in which to complete his work and escape than if only one thickness of paper were used.

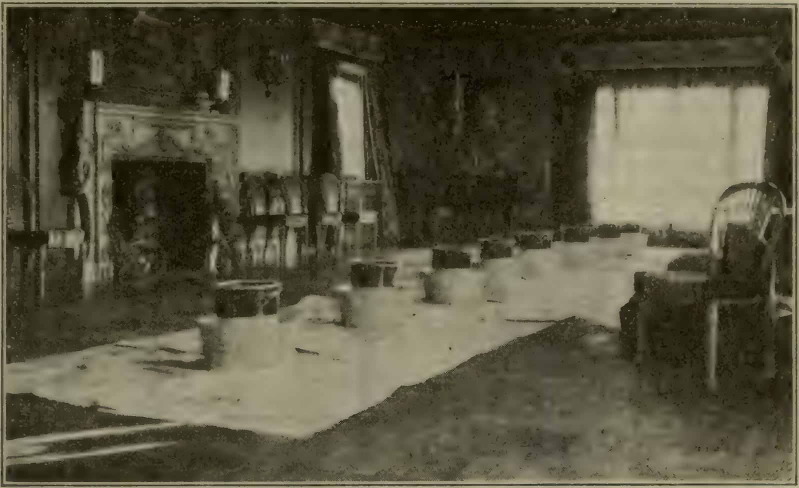

FIGURE 11.—A dining room with table and rugs placed to one side. Eight 4-gallon crocks are shown with acid and water in them. The sacks of cyanide have not been placed beside the containers, as this is one of the last steps before the gas is generated. Note the arrangement of newspapers to catch any chance spattering of acid during the evolution of the gas

When all is ready, the fumigator should start upstairs in the room farthest from the stairway, gently lower the bag of cyanide into the generator containing the acid and water, leave the room, and close the door. He should repeat the operation in the other rooms on that floor, proceed to the downstairs rooms and start the generators there, then leave by a predetermined exit. If all the rooms on the first and second floors are fumigated as a single unit (fig. 13) by using one or two large containers on the first floor, all the inside doors are left open and the containers are located close by the exit door.

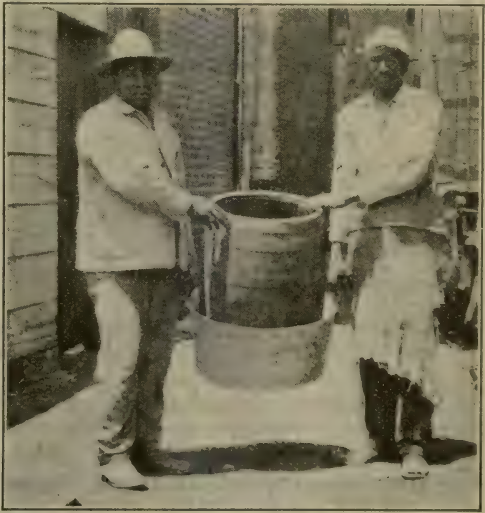

FIGURE 12.—A 30-gallon barrel in a galvanized-iron washtub. To carry such equipment into and out of buildings requires two strong men unless the chemicals are added and emptied by pails. These men are about to empty into a city drain the residue following a hydrocyanic acid gas fumigation

In buildings equipped with fire-alarm systems which are set off by heat, the generation of hydrocyanic acid from large charges of cyanide in barrels directly beneath the wires may cause the alarm to ring. This can be avoided by properly placing the barrels.

If the cyanide is well wrapped, one person will have sufficient time to start the generators in all the rooms in an ordinary house before there is danger of being overcome by the gas. In larger houses two or more persons can work together. A definite plan should be made and rehearsed in advance, so that each man knows just what he has to do and when he is to do it. The work should be done rapidly, but not recklessly or nervously. If a charge is overlooked, let it go; to go back is dangerous.

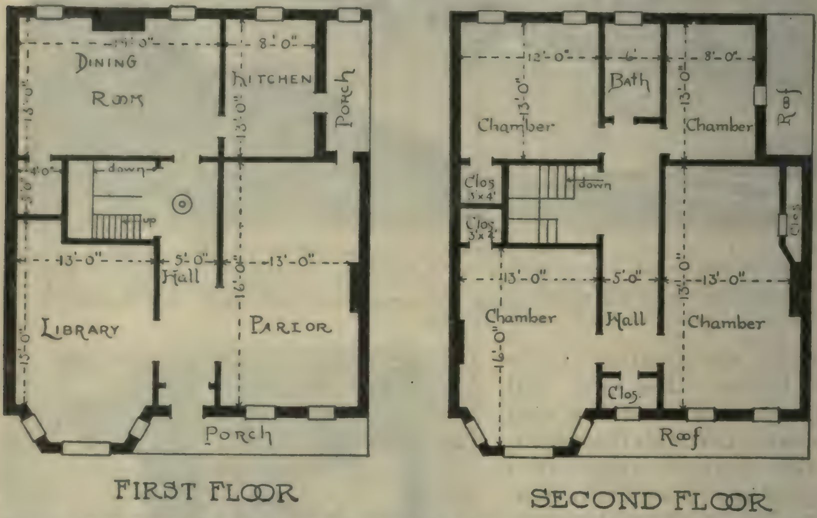

FIGURE 13.—Floor plan of first and second stories of a dwelling fumigated by the pot method. One oil barrel was used for the entire house and was placed in the hallway on the first floor. Insects placed in rooms on the first and second floors as a test were killed, indicating good results when but one container is used. It is generally believed that better results follow the fumigation of each room as a separate unit, and this is undoubtedly true in some instances. The 1-container method is cheap and easy

PRECAUTIONS AGAINST SPATTERING FLOORS, RUGS, AND OTHER FURNISHINGS

The fumigator should guard against the possibility of the acid-water mixture spattering out of the container during the rapid evolution of the gas after the cyanide has been added. Too large a dosage of cyanide for the container will cause this spattering. He should never put a 3-pound charge of cyanide into a 3-gallon crock, but use a 4-gallon crock instead. For a 2-pound charge he should use a 3-gallon, or larger, crock. Newspapers or other papers should be spread on the floor beneath and around the container (fig. 11) and, while the containers should be at least 4 feet from furniture, if it is necessary to place them closer, the sides of the furniture should be well covered with newspapers.

LENGTH OF EXPOSURE

The duration of the exposure may be varied to suit the requirements. An 8 to 12 hour fumigation is desirable because it gives the gas an opportunity to penetrate thoroughly. In general, the longer the fumigation period the smaller the dose required, although in a loosely constructed house, such as the ordinary American frame dwelling, a killing concentration can not be maintained for any great length of time.

When necessary, the period of fumigation can be reduced to as little as 4 hours, and with an increased dosage a 2-hour fumigation has given satisfactory results in killing bedbug and flea infestations. Short exposures are necessary in rooming and boarding houses that can not be vacated for very long periods.

EMPTYING CONTAINERS

After fumigation by the pot method, and the thorough ventilation of the building as described on page 17, the residue must be emptied from the containers. Sometimes a part of it becomes crystallized, or "frozen," and must be broken up with a stick. Sometimes the chemical reaction is imperfect because not all the cyanide comes into contact with the acid. For this reason the operator should proceed with caution until he is assured, by its failure to bubble, that the residue is safe to handle. This residue is somewhat acid. In handling the containers one should breathe as little as possible and keep the head turned aside.

The residue can be dumped down street drains or even flushed quickly down house toilets. It is better, however, to dig a hole in the ground and pour the residue into it: after the residue has sunk into the earth the hole should be filled.

THE CALCIUM CYANIDE METHOD

Calcium cyanide in dust form can be used successfully for household fumigation. The dust is extremely sensitive to moisture, and when it is exposed to air a chemical reaction between the calcium cyanide and the atmospheric moisture takes place and results in the liberation of hydrocyanic acid gas. The gas is given off so rapidly that the material is dangerous to use unless the operator is equipped with a gas mask. It should be used only by a professional fumigator.

Inasmuch as calcium cyanide dust is applied merely by spreading it thinly on a strip of paper on the floor, its use is more convenient than the pot method because it eliminates the disagreeable task of measuring and weighing the chemicals, the danger of spilling the acid and of cracking the jars, and the necessity of emptying containers after the gas has been generated.

METHOD OF APPLICATION

After a room has been tightly sealed in preparation for fumigation, strips of paper or newspaper should be laid across the floor. The fumigator, wearing a mask, should then distribute the necessary number of cans of the fumigant, loosen the caps, quickly scatter the contents over the paper strips in as thin a layer as possible (fig. 14), and leave the room.

The operator should always begin distributing the powder at the point farthest from the door, so that he will be working away from the gas that is being given off from the exposed material. After the fumigation the paper on which the calcium cyanide has been spread can be rolled up and thrown away. A small percentage of the available hydrocyanic acid gas may be retained in the dust after the fumigation; hence, it is advisable to dispose of the residue outside the building. After all the hydrocyanic acid gas has been given off, the residue is nonpoisonous.

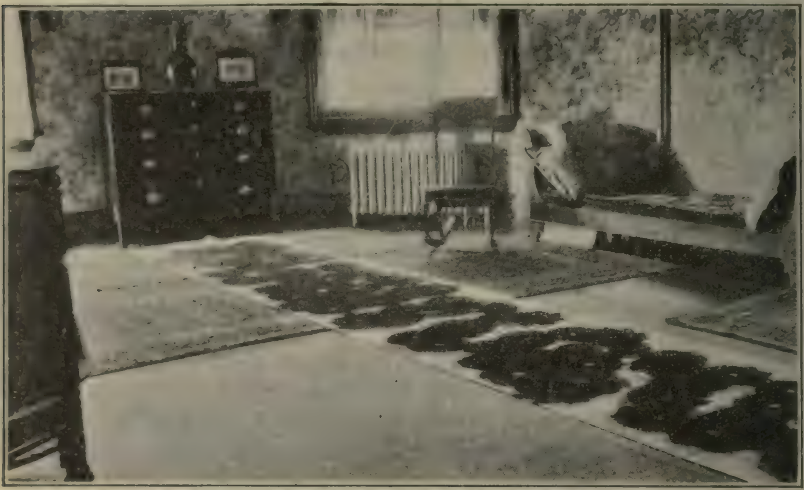

FIGURE 14.—Calcium cyanide dust laid on a paper runner the length of a room. Note that the room has not been disarranged in the least. Hydrocyanic acid gas begins to be evolved as soon as the material is exposed to the moisture in the air. When rooms are opened for ventilation, a strong breeze may blow the residue about the room

QUANTITY REQUIRED

The quantity required will depend upon the percentage of available hydrocyanic acid gas in the fumigant. If, for example, it contains from 50 to 55 per cent available hydrocyanic acid gas, a dosage of 1 pound per 1,000 cubic feet of space is needed for satisfactory fumigation, with an exposure of from 8 to 24 hours.

The material can be purchased in cans of various sizes, adapted for sprinkling the fumigant on the floor. Labels on the cans give the strength of the contents and directions for dosage and application. Calcium cyanide sells for $1.35 per pound.

THE USE OF LIQUID HYDROCYANIC ACID

Liquid hydrocyanic acid is a volatile, colorless liquid boiling at a temperature of 79.9° F. On exposure to air it gives off the same gas that is generated by the pot or other methods. It is too dangerous to be handled by the average householder and should be applied only by an expert. In the fumigation of houses the gas is distributed by means of a system of ¼-inch piping or by the use of rubber hose. The liquid, which is marketed in cylinders containing 30 or 75 pounds, is forced into the piping system from the outside of the house by means of compressed air. (Fig. 15.) It is broken up into a fine spray by means of spray nozzles and vaporizes immediately. A dosage of 5 to 8 ounces of the liquid per 1,000 cubic feet of space gives satisfactory results.

The cost of liquid hydrocyanic gas ranges from $1.25 per pound for single 75-pound cylinders to 80 cents per pound for quantities in excess of 10,000 pounds.

THE USE OF HYDROCYANIC ACID ABSORBED IN INERT MATERIAL

Hydrocyanic acid absorbed in diatomaceous earth or other inert material is available as a household fumigant in the form of a coarse, brown, slightly damp, loose granular material (fig. 16) or in the form of compressed waferlike disks. (Fig. 17.) In either form it should be used only by professional fumigators. It comes in tin cans and upon exposure to air gives off the hydrocyanic acid gas so quickly that gas masks are necessary. It may be purchased either with or without small quantities (about 5 per cent) of chloropicrin, which produces a lachrymatory effect and warns any persons exposed to the gas.

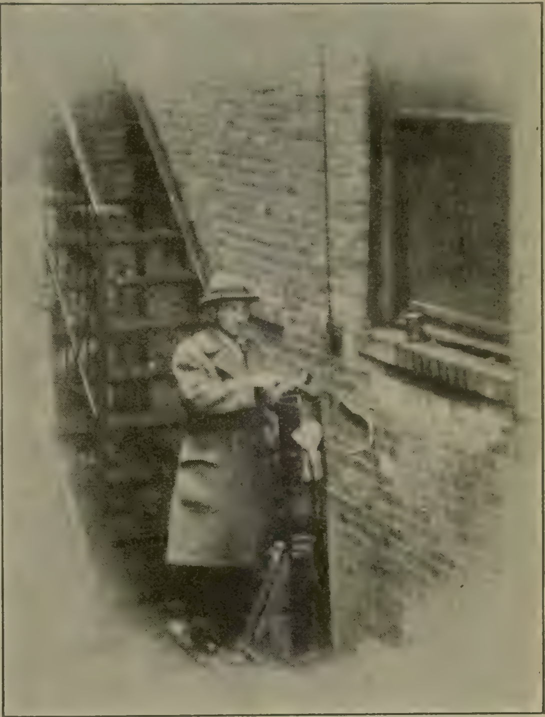

FIGURE 15.—A cylinder of liquid hydrocyanic acid attached to a pipe line through which the liquid can be pumped into the building

GRANULAR MATERIAL

The granular material consists of nearly equal parts by weight of liquid hydrocyanic acid and diatomite. It is packed in hermetically sealed cans and is sold on the basis of the net content of hydrocyanic acid—20 grams, 100 grams, 500 grams, 1,000 grams, etc. It costs from $1.00 to $1.20 per pound of hydrocyanic acid, depending upon the amount purchased. If a warning gas is included an additional 10 cents per pound is added. It runs freely from an opening about 1½ inches in diameter and is convenient for fumigating single rooms or houses, since the cans are not bulky and are easily transported. No extra equipment, such as crocks, cylinders, or piping, is needed, and the cans, and the residue, which is nonpoisonous, can be thrown away as harmless after the fumigation.

After the room or structure to be fumigated has been sealed, strips of paper on which to spread the fumigant are placed on the floors and the necessary number of cans are then distributed. Since the gas is given off with great rapidity when the material is exposed to the air, a gas mask must be worn during the entire fumigation. A small hole is punched in each can to relieve the pressure of free

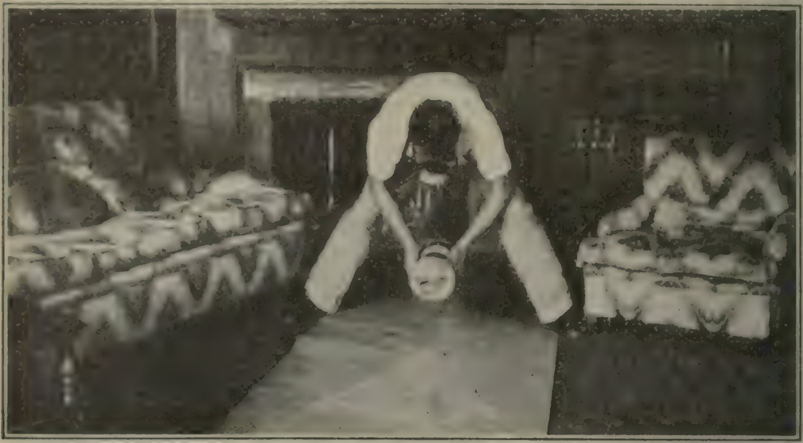

FIGURE 16.—A granular diatomaceous earth impregnated with hydrocyanic acid. Note that the man, wearing a gas mask, is pouring the material out of the can, in which it comes, onto a roll of paper spread directly upon the rug. During fumigation all the hydrocyanic acid gas is evolved from the material. After ventilation the residue can be rolled up in the paper and thrown into the trash without danger of poisoning man or animals

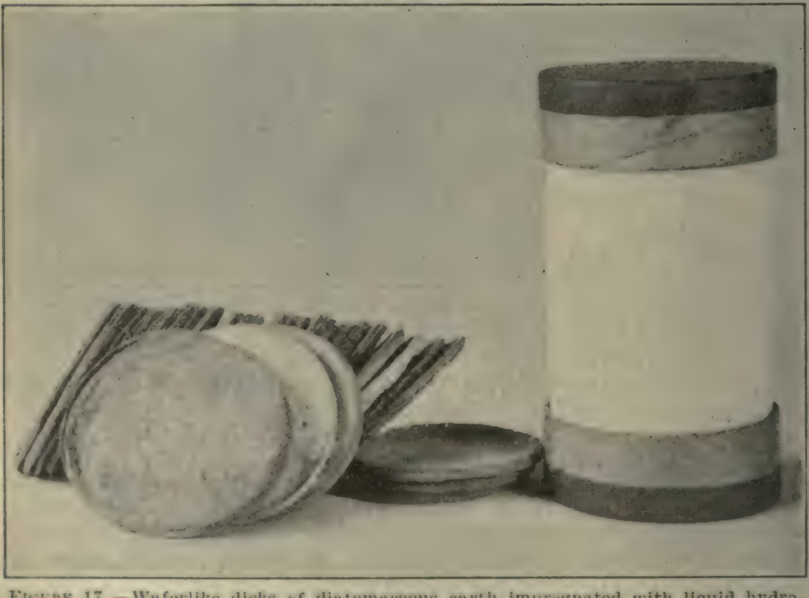

FIGURE 17.—Waferlike disks of diatomaceous earth impregnated with liquid hydrocyanic acid. They are marketed in cans, one of which is shown to the right

gas that has accumulated. In making this initial opening it is well to tip the can away from oneself in order not to be sprayed with the first outrush of gas. A larger hole is then made and the contents of the can are at once poured onto the paper in a layer not more than one-half inch in thickness. (Fig. 16.) A special hammer having a tempered cutting head which cuts a 1½-inch opening in the top of the can with one stroke is manufactured.

The fumigator should always work from upper to lower floors and should first empty the can farthest from the point of exit and gradually work his way toward the door. For the sake of safety, at least two men should always work together, and enough men should be available so that one man need not empty more than 30 cans. When more than 100 cans are required, they should be opened outside the house by completely removing the tops of the cans and replacing them with rubber caps. This procedure saves time and simplifies the work of application.

After the fumigation the building can be ventilated and the empty cans and residue discarded.

WAFERLIKE DISKS

Hydrocyanic acid is sometimes sold absorbed in a bibulous material pressed into waferlike disks (fig. 17) resembling circles of heavy cardboard. These disks must be used only by an experienced fumigator while wearing a gas mask. They are used in the same manner as the hydrocyanic acid absorbed in the coarser material just discussed, but the disks are much cleaner and make fumigation and cleaning up easier. The disks, each of which contains approximately one-half ounce of liquid hydrocyanic acid, should be distributed on several layers of paper; otherwise the liquid they contain is likely to injure the finish of the floors. The disks are also sold on the basis of net content of hydrocyanic acid, the cost being the same as for the granular material.

VENTILATING A HOUSE AFTER FUMIGATION

At the end of the fumigation period the house must be ventilated before it can be occupied. If the operator has a gas mask, he can enter the building and proceed to open all windows and doors.

Large buildings, such as those shown in Figures 1, 18, 19, and 20, should be fumigated and ventilated only by professional fumigators equipped with gas masks. In a small building, such as an 8-room 2-story house, the ventilating can be done from outside the house without the use of a gas mask. If the various rooms have been fumigated as separate units by closing their doors into hallways, a window in each room must be opened from outside. Perhaps the easiest method of opening windows in the upper stories is to attach a cord or wire to the lower part of the upper sash. A strong pull will open the window. Windows and doors on the first and basement floors can be opened from without.

If the rooms of the house have been fumigated as a single unit from a center hall, opening a first-floor door and one or more second-story windows will effect a good ventilation. If it is difficult to open upper windows, the lower floor and basement may be ventilated first and then upper rooms may be opened one at a time until no strong odor of the fumigant remains.

If the atmosphere is light and airy and a breeze is blowing, a house can be ventilated within 30 minutes so that it is safe to enter and

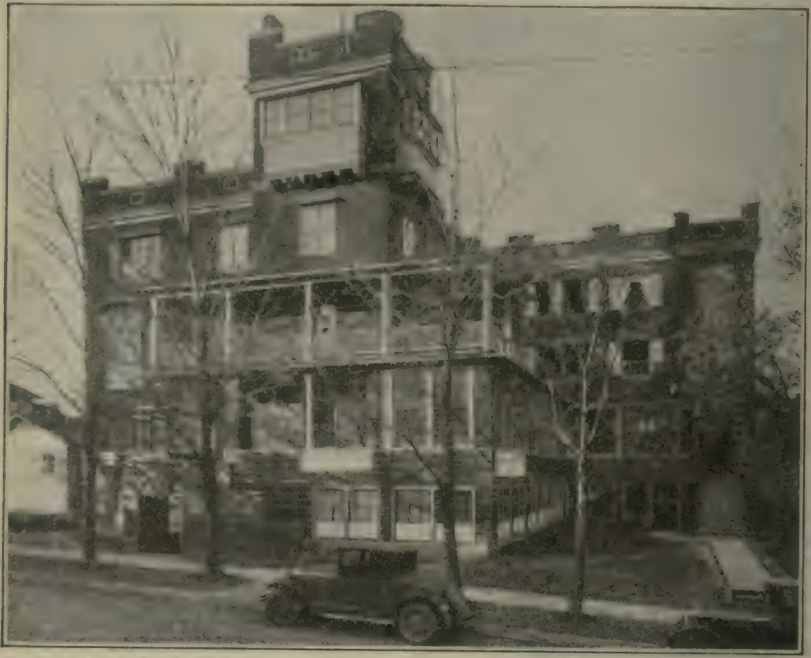

FIGURE 18. A frame structure used for school purposes in a large northwestern city. Although set directly on the street, and close to other buildings, it was fumigated with hydrocyanic gas for the destruction of bedbugs during the summer vacation. The sidewalk was not roped off, as is sometimes done in congested districts

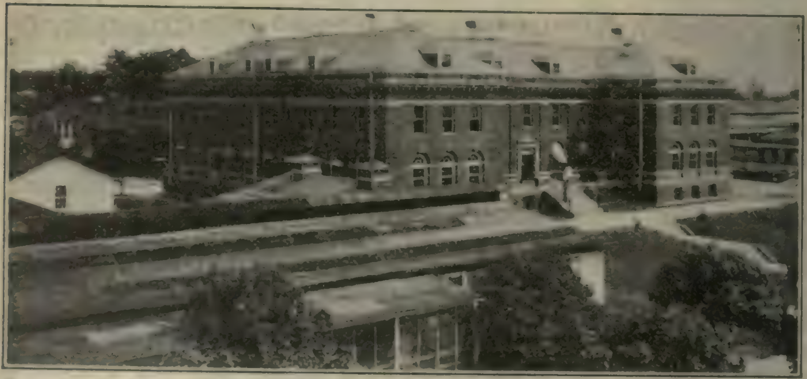

FIGURE 19.—Large brick dormitory at Walter Reed Hospital, Washington, D. C. This building was fumigated with hydrocyanic acid gas from the attic rooms to the commissary in the basement. Note proximity of surrounding buildings, which were all occupied during the fumigation. The entire building was vacated for a 24-hour period

remain, provided the windows are kept open. The gas, being lighter than air, escapes upward quickly. If the day is muggy and humid, however, ventilation proceeds very slowly. As a rule, one can enter a house safely when there is no strong odor of gas. A bitter taste is a danger sign.

If the house is occupied, all windows should be left open for several hours and some should be left partly open for at least 24 hours after ventilation. The bedding should be well aired. If the rooms are occupied the night after fumigation, the windows should be kept wide open throughout the night, since the gas may cling to mattresses and pillows for several hours and may be given off in a dangerous amount if thorough ventilation is not maintained.

GAS MASKS

Several types of gas masks suitable for fumigation work are on the market. The best has a face piece of leather, rubber, or rubberized fabric which can be adjusted to fit tightly across the forehead, along the sides of the face, and under the chin. This face piece is provided with large eyepieces and is connected by a short flexible tube to a metal canister containing absorbent materials. (See cover illustration.) These materials, either by absorption or by chemical reaction, remove certain gases and vapors from the air. An arrangement of valves in the gas mask requires all air breathed by the wearer to pass through the chemicals in the canister, which absorb the poisonous gas.

FIGURE 20.—Combination of stores and dwelling apartments. The corner store was fumigated successfully with hydrocyanic acid gas after all occupants of the building had signed an agreement to vacate their quarters for a 2-hour fumigation of the store. The fumigator had access to the building at the right, but no gas penetrated its walls.

Canisters are of different types and protect against many different gases. A fumigator should be sure that the canister he is using protects him against hydrocyanic acid gas. If he is using a form of cyanide that contains chloropicrin as a warning gas, the ordinary canister for hydrocyanic acid gas will not be adequate and one that will protect against both gases must be used.

A canister will last for only a certain period, which depends upon the concentration of the gases to which the canister is subjected, the length of the exposure, and the manner in which it is stored when not in use. As supplied by the manufacturer, the canister is sealed by a cap over the inlet valve and by a cork in the nipple. Stored in this condition and without use the canister should last a year. If air is allowed to enter, the contents of the canister deteriorate rapidly. A fresh canister is good for several hours of continuous use. When it begins to give out, the gas fumes will penetrate the mask. When this occurs the wearer should immediately go into fresh air and replace the canister with a new one. Canisters are cheap.

Before being used a mask should always be tested for leaks by closing the bottom opening of the canister with the hand and attempting to breathe with the mask on. If no air can be obtained the mask is fit for use.

TREATMENT OF PERSONS OVERCOME BY GAS

A person overcome by the gas should be removed at once from the poisonous atmosphere and placed in fresh, but not cold, air. Chilling should be avoided as it increases the liability to pneumonia. If breathing has stopped, artificial respiration should be started and continued until normal breathing is restored. The victim should be wrapped in warm blankets and all tight clothes loosened around the neck, chest, and waist. If possible, a mixture of oxygen and 5 per cent carbon dioxide should be administered for 20 to 30 minutes, with the aid of a specially designed inhalator.

Other forms of medication are said to be of little use in the immediate treatment of poisoning by noxious gases.

Alcohol should not be administered and emetics are useless. Water should not be thrown on the patient in an effort to revive him, for this will do more harm than good. Under no circumstances should a gassed person be allowed to exercise; he should be made to lie down and remain as quiet as possible.

DO NOT FUMIGATE WHEN ALONE, OR WHEN CLOTHING IS WET WITH PERSPIRATION

No one should conduct a fumigation alone. He should be accompanied by one or more persons, and one of the party should be kept in reserve in order to assist in case a fumigator feels the need of fresh air. If a person feels the slightest faintness or weakness while fumigating he should call to his companion to assist him outside, where he should lie down and rest until he feels normal once more. Dizziness, weakness in the knees, and nausea are all indications that one should seek the open air. In properly conducting a fumigation none of these symptoms should develop.

Large buildings that have been closed for fumigation are usually hot and the fumigators are apt to perspire freely. It is well not to start a fumigation while wearing clothing wet with perspiration and care should be taken never to expose oneself unnecessarily to the fumigant.

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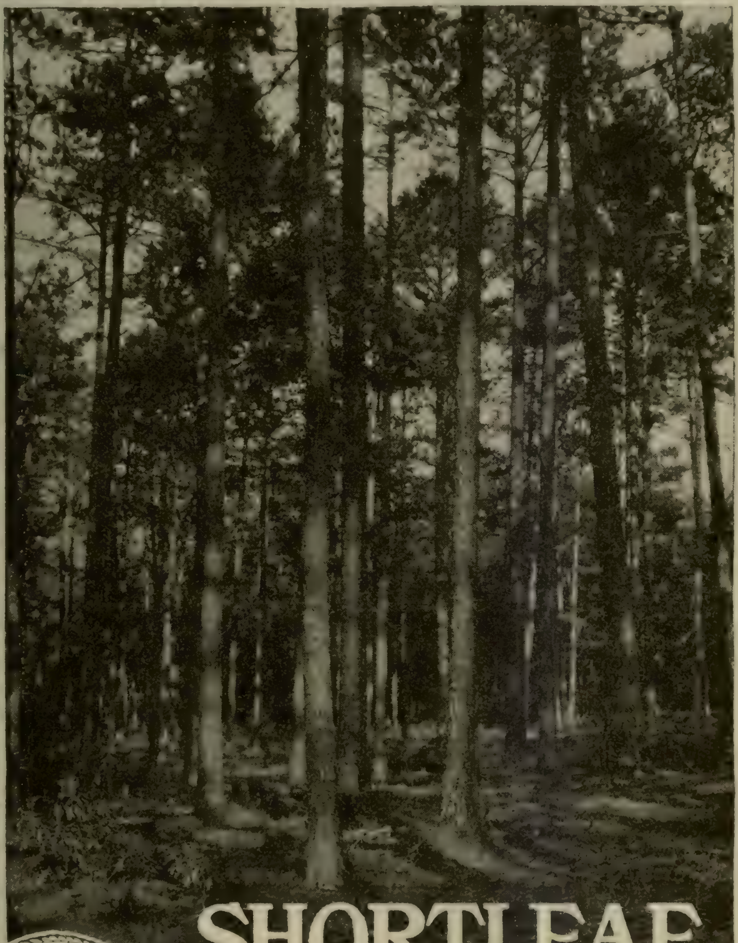
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1671

Rev. Oct '40



SHORTLEAF PINE

TIMBER is an agricultural crop—grown from the soil. Timber will be needed in the future; therefore young trees are valuable now.

Timber is a local and national necessity, and the people will pay enough for it to cover the cost of production plus a fair profit to the grower.

Timber is a farm savings bank to be drawn upon in times of extra need. If we check on it only to the extent of cutting the growth, or interest, the capital remains untouched and the investment continues undiminished. Thrifty growing timber rightly protected and cut often yields more profit than money at 6 per cent interest.

Timber growing is usually not a major project on the farm, but timber products often bring in a substantial part of the farm income.

Better methods of soil building and intensive soil cultivation have diminished the need for clearing up new lands for crop production. This favors the growing of timber as a crop on the less fertile or more broken parts of the farm, and makes it a part of the regular farm program.

Shortleaf pine is one of the most profitable forest trees to grow as a crop over a large area of the uplands and mountains from New Jersey to Georgia and west to Oklahoma and Texas.

This bulletin is a revision of and supersedes Farmers' Bulletin 1534, Shortleaf Pine Primer.

Washington, D. C. **Issued September, 1931**

SHORTLEAF PINE

By Wilbur R. Mattoon, *Extension Forester, Forest Service*

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GROWING SHORTLEAF PINE AS A CROP

SHORTLEAF PINE (*Pinus echinata* Miller), or shortleaf yellow pine, has certain features which make it a desirable and profitable tree to grow as a crop. It grows rapidly, produces high-quality, soft-textured wood, and easily perpetuates itself by means of an abundance of seed and also, if the young pines are killed back, by sprouting up vigorously from the ground to form another forest.

Shortleaf pine grows well on the uplands, including the piedmont and the lower mountain sections, from New Jersey south and west to eastern Oklahoma and eastern Texas.

Timber is an essential material for successfully operating the farm—for houses, barns, fences, telephone poles, and fuel wood. Some parts of nearly every farm are broken, steep, or worn-out lands, best suited to timber as a crop and also most profitable when used for that purpose. The farm timberland, in addition to supplying farm needs, often produces a surplus of timber products for sale in the market. Well-managed farm woodlands have many times been the means of changing the farm balance sheet from loss to profit. The growing of timber on the farm is justified as a farm enterprise.

Good forest practice means, for the most part, protecting the land at all times from fire and rightly using the ax and saw. The aim of this bulletin is to offer suggestions that may be helpful in the growing of shortleaf pine as a profitable crop.

> Timber will always be needed for operating the farm—for houses, barns, fences, telephone poles, and firewood.
>
> A rational farm program includes growing timber for home use and for sale.

What is "shortleaf" pine?

The true shortleaf pine is known also as yellow pine, and, in some places, as rosemary pine. In the coastal-plain region from North Carolina to Louisiana the term "shortleaf" is often applied to the loblolly pine to distinguish it from the longleaf pine, as both loblolly and longleaf are often found growing together.

The true shortleaf pine finds its home in the piedmont section and on the lower slopes of the Allegheny Mountains. It grows in well-drained clay or gravel loams and therefore is found on ridges and on warm, south-facing slopes. It is found in 24 States, from the southernmost part of New York, through New Jersey, Pennsylvania, West Virginia, southern Ohio, southern Indiana, southern Illinois, Missouri, southeastern Kansas, eastern Oklahoma, and eastern Texas, and all the States east and south of these. The botanical range and the territory in which it is commercially important are shown in Figure 1.

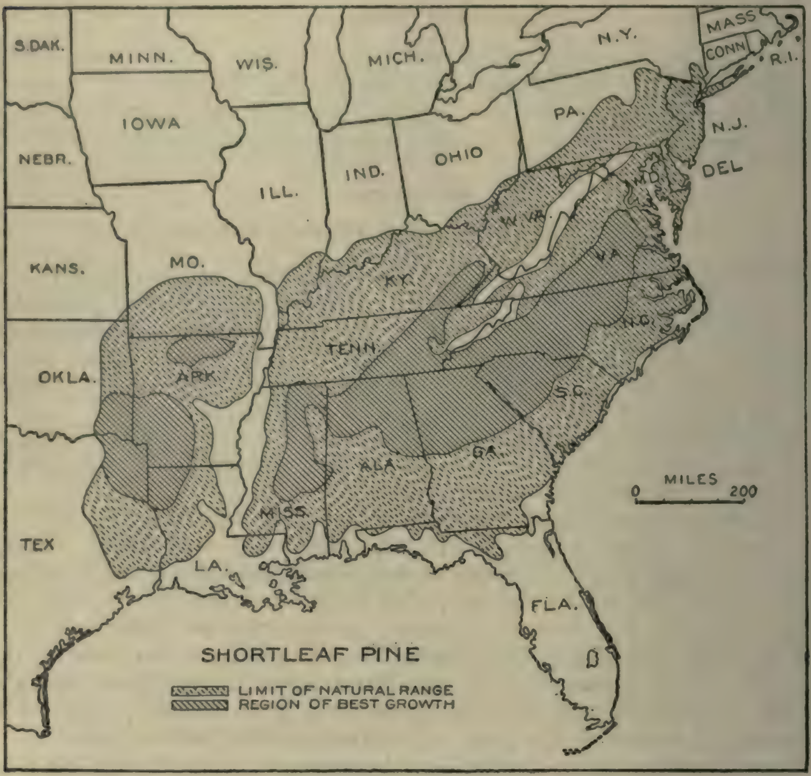

FIGURE 1.—Map showing the range of shortleaf pine

How can you tell shortleaf from other pines?

The leaves, or straws of shortleaf pine are mostly from 3 to 5 inches in length and occur in clusters of either two or three. On vigorous branchlets clusters of three leaves prevail. The sand pine of Florida and southern Alabama has similar leaves, but they occur always in clusters of two leaves each. The loblolly pine, shortleaf's most abundant associated pine, regularly has three leaves in a cluster. The cones, or burs, of shortleaf are mostly about 2 inches long, with very fine prickles on the cone scales. When open and on the tree they look to be the size of small pullet eggs. The trunk is remarkably straight and clean, "as smooth and straight as the mast of a Salem clipper—a pleasure to the eye and to the sawmill man." Unlike all other important commercial pines, shortleaf pine sprouts vigorously when cut or burned back during early life, and thus successfully reproduces itself.

TIMBER GROWING ON THE FARM MEANS:

Improving woodlands by right methods of cutting and protection

Reforesting vacant and unprofitable farm lands

Using farm-grown timber to the best advantage

Marketing home-grown timber at a fair profit

How can the farm forest be made more profitable?

The chief reasons for failure to make farm woodlands profitable are lack of good management, failure to protect them from fire and excessive grazing, ignorance concerning methods of cutting and local timber values, and undeveloped markets. The owner must know how to handle his woods and market the product if the forest tract is to be made profitable. (Fig. 2.) Wherever forest land is close to centers of consumption, numerous examples of profitable management can be found. Generally in the eastern United States the value of timber is now such as to make its production as a crop bring a fair net return on the investment.

GROWTH OF TREES

How fast do shortleaf pine trees grow?

Shortleaf is a rapid to moderately rapid growing pine.

Its rate of growth depends a great deal on the region and the local conditions. Often associated with loblolly pine, red oaks, hickories, and sweet gum, shortleaf pine maintains its place in the "mixed forest." It grows best and most profitably, however, in pure stands; that is, stands composed only of shortleaf pine. In this manner it occurs extensively, coming up in abandoned fields and in openings in the woods.

Many measurements have been made of the trees in pure pine stands fully stocked with trees (i. e., no open spaces). Here the growth of the individual tree is less than it would be in the open, but the growth in close stands returns the largest yield of wood per acre.

The average size of the trees at different ages grown in fully stocked stands is shown in Table 1, and also the average number of trees per acre. It is obvious that the better the land the more rapid the growth, and the poorer the land the slower the growth. This

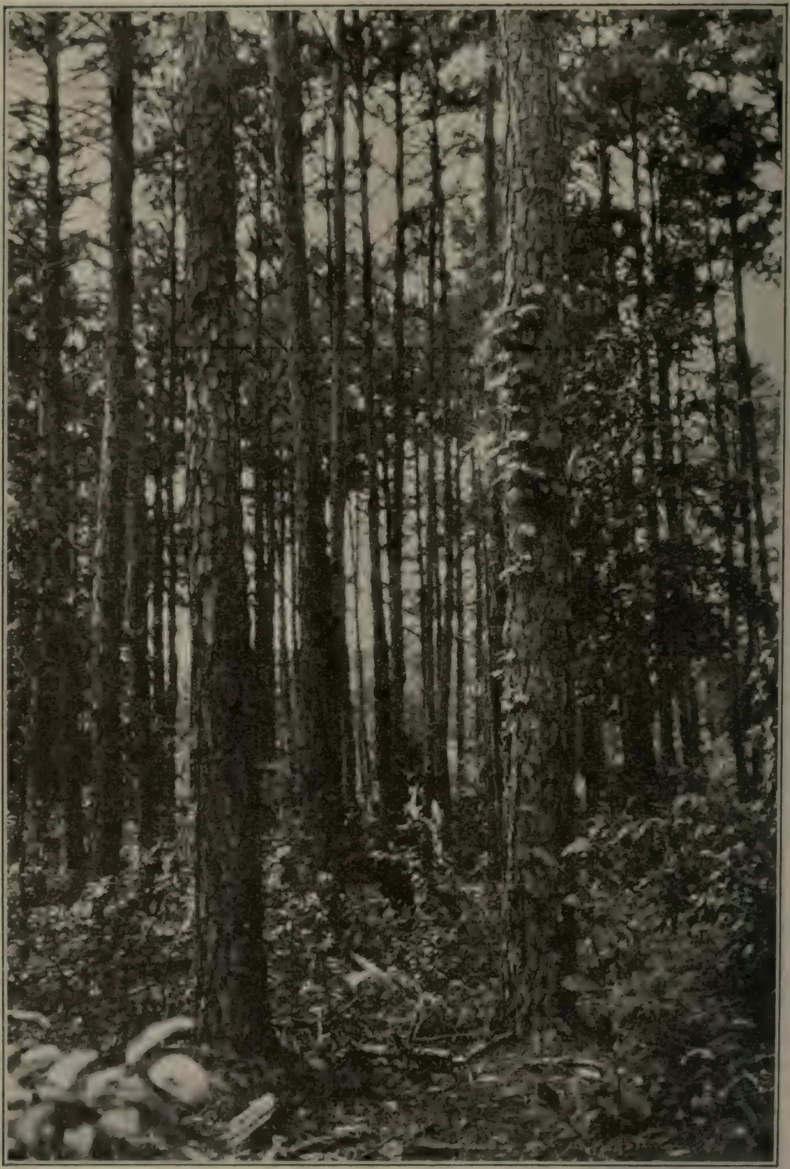

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FIGURE 2.—Thrifty stand of shortleaf pines making rapid growth as the result of complete protection from fire. The ground cover of young trees and other plants is beneficial in shading the ground

also applies broadly to whole regions of the country. For example, at high altitudes and in the more northern and more southern parts of the range of shortleaf pine the rate of growth of trees is relatively slow. So all kinds of land on which growing stands were measured have been thrown into three classes, namely, good, average, and poor. In measuring the stands no account was taken of the very slow-growing trees—stunted, dying, or "suppressed" trees—all of which should have been thinned out. The better-growing or "dominant" trees were studied and measured. These amount to about two-thirds of the total stand of trees—less in young stands and more in older stands.

Shortleaf pine trees in fully stocked stands at an age of 30 years, for example, on good land should average about 63 feet in height and 8.8 inches in diameter (at breast high); on average quality land, about 49 feet and 6.6 inches; and on poor quality land about 35 feet in height and 4.8 inches in diameter. A fully stocked stand 30 years old, on average land would contain about 505 larger, or dominant, trees per acre, which would be about two-thirds of the total number of trees.

In most calculations it is best to use the column for average land (Table 1). Trees at 40 years of age on average land will be found to be about 61 feet in height and 8.4 inches in diameter.

TABLE 1.—*Rate of growth of shortleaf pine trees in fully stocked or fairly crowded stands, on three grades of land and at different ages*

Age of trees	Height of trees [1]			Diameter of trees (at breast height) [1]			Number of trees per acre	
							Thrifty or dominant trees	Trees 4 inches and over in diameter
	On good land	On average land	On poor land	On good land	On average land	On poor land	On average land	On average land
Years	*Feet*	*Feet*	*Feet*	*Inches*	*Inches*	*Inches*	*Number*	*Number*
15	33	26	19	4.6	3.5	2.5	1,075	[2] 330
20	44	34	25	6.1	4.5	3.2	850	[2] 780
25	54	42	30	7.5	5.5	4.0	675	990
30	63	49	35	8.8	6.6	4.8	505	825
35	71	55	40	9.9	7.5	5.5	390	660
40	78	61	44	10.9	8.4	6.1	320	545
45	85	66	47	11.8	9.1	6.8	275	460
50	90	70	50	12.6	9.8	7.3	245	405
55	95	74	53	13.3	10.4	7.8	220	360
60	99	77	55	14.0	11.0	8.3	200	330
65	103	80	57	14.6	11.5	8.7	190	300
70	106	82	59	15.2	12.0	9.1	175	280

[1] The very slow growing trees—sickly, overtopped or suppressed—were not measured or included. The more promising, or dominant, classes of trees only were measured. These comprise about two-thirds the total number of trees.

[2] At this age only the very fastest growing trees in the stand have reached a size of 4 inches or over in diameter.

One point should not be overlooked, namely, that shortleaf pine averages small in the size of the individual trees, but naturally grows in crowded stands of many trees per acre. Thus its yield of timber or wood per acre or growth per acre is relatively high.

What factors determine the rate of growth?

The health of the tree is all important in determining its growth. (Fig. 3.) Trees can be starved because of lack of food and water. To make their own food, pines require little besides water and sunlight. The pines as a class can thrive on soil that would be too deficient in potash, phosphoric acid, and nitrogen for most of the hardwood trees like the oaks, poplar, walnut, maple, beech, and hickories. But a hard, dry soil prevents proper root development and root activity. The tree is stunted as a result. Trees may be overcrowded so that even on good soil there is not enough moisture for each, and also not enough sunlight. Fire is a powerful agent in checking the rate of growth, if in fact it does not kill the tree. This subject is treated further on pages 35 to 37.

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FIGURE 3.—Timberland owners discussing with a forester the rate of growth and the management of shortleaf pines. A knowledge of what makes trees grow and how to keep the woods thrifty and safe from fire and insects is essential in using land most profitably

Do tree trunks lengthen?

Yes; but only by new growth at the top. Once the side limbs are formed or set, they remain in that same position throughout the life of the tree, or until they die and drop off. All limbs or branches from the main trunk reach to the heart or center of the tree.

SCALING LOGS

What is a log scale rule?

A scale or rule which shows how many board feet can be cut from logs of various sizes. Most commonly, the diameter of the log in inches is measured inside the bark at the small end, and the length in feet over all.

Does it make any difference what log rule is used for measuring and selling logs?

Yes; a great difference both in the amount of timber and in the resulting money return.

The Doyle rule, although in common use in the South, is unfair to the seller for logs below about 28 inches in diameter. In the early days of large and cheap virgin timber, when narrow and knotty boards were worthless, it was fairly satisfactory, but for scaling small-sized timber, such as second-growth southern pine, it gives such small volumes for small logs as to make it unsatisfactory. On the national forests the Scribner rule (in the decimal C form) is standard. It is more fair than the Doyle rule for small logs, but reasonably careful sawing should result in obtaining from 10 to 20 per cent more lumber than even this rule gives for second-growth timber.

TABLE 2.—*The contents of logs, in board feet, scaled by the International log rule (using saw cutting ¼-inch kerf)*

Diameter at top end of log inside bark (inches)	Length of log in feet						
	8	10	12	14	16	18	20
	Contents of log in board feet						
6	7	10	13	16	19	23	27
7	12	15	19	24	28	33	39
8	16	21	27	33	39	45	52
9	23	29	36	43	51	59	68
10	29	37	45	54	64	75	86
11	36	46	57	68	80	92	105
12	44	57	70	83	97	111	127
13	52	68	83	100	116	133	151
14	62	80	98	117	136	156	176
15	73	94	114	136	157	180	204
16	84	108	131	156	181	207	233
17	96	123	149	177	205	235	265
18	110	139	169	201	232	265	299
19	123	156	190	225	261	297	335
20	138	174	212	251	290	330	372
21	152	193	234	279	321	366	412
22	168	214	259	307	354	404	453
23	186	235	285	337	388	442	497
24	203	257	311	367	424	481	542

TABLE 3.—*The contents of logs, in board feet, scaled by the Doyle log rule*

Diameter at top end of log inside bark (inches)	Length of log in feet						
	8	10	12	14	16	18	20
	Contents of log in board feet						
6	2	2	3	3	4	4	5
7	4	5	7	8	9	10	11
8	8	10	12	14	16	18	20
9	12	16	19	22	25	28	31
10	18	22	27	31	36	40	45
11	24	31	37	43	49	55	61
12	32	40	48	56	64	72	80
13	40	51	61	71	81	91	101
14	50	62	75	87	100	112	125
15	60	76	91	106	121	136	151
16	72	90	108	126	144	162	180
17	84	106	127	148	169	190	211
18	98	122	147	171	196	220	245
19	112	141	169	197	225	253	281
20	128	160	192	224	256	288	320
21	144	181	217	253	289	325	361
22	162	202	243	283	324	364	405
23	180	226	271	316	361	406	451
24	200	250	300	350	400	450	500

For small timber, such as second-growth pine, the International log rule (Table 2) gives log volumes which are very close to what can be sawed out by using good methods. Careless sawing will give a lower volume of square-edged boards than the logs scaled by this rule, so that it gives the millman a chance to test his own efficiency in this respect. Producers of small logs will benefit when this or some equally close rule has come into general use. The sale of logs by the International rule is recommended.

As a comparison, a log measuring 10 inches in diameter inside the bark at the small end and 16 feet long, when carefully sawed with a circular saw of ordinary thickness (¼-inch kerf) should, according to the International rule, turn out 64 board feet. For the same log the Doyle rule (Table 3) would show 36 board feet or only about one-half the amount that can be actually sawed and that is credited to it by the International rule.

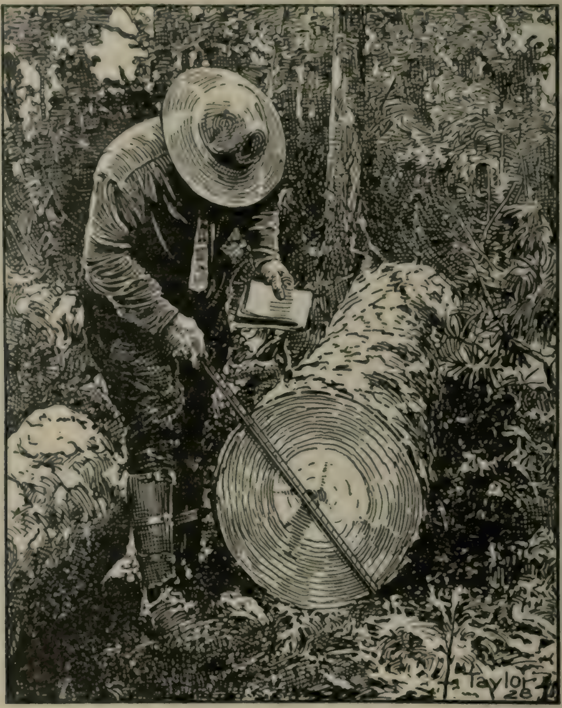

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FIGURE 4.—Scaling the contents of a log in board feet, using a log scale stick. Measurements are taken inside the bark at the smaller end of each log

How are logs scaled?

The diameter of the small end of the log inside the bark is measured in inches, and its length taken in feet. If a scale stick is used, the contents of the log are read directly from the stick. (Fig. 4.) Otherwise it can be read from tables, such as Table 2 or 3. These readings are for straight and sound logs. Thus, the scaling of sound and straight logs is a simple matter.

Experience and special knowledge are required to determine the allowance that should be made for defective logs. The problem is to ascertain how much deduction from the scale should be made to equal the loss resulting from hollow centers, rot, crook, and other defects. Observations at a sawmill should help, as does also assistance from an experienced scaler. Defect often requires deductions of 5 to 10 per cent, and sometimes as much as 15 to 20 per cent of the scale.

ESTIMATING STANDING TIMBER

What is meant by the volume of a tree?

The volume of a tree is its contents, usually expressed in terms of board feet of lumber, cords of wood, crossties, or cubic feet. It is customary to include only the merchantable contents of the trunk between the stump and the top that is left in the woods. Saw logs are cut from the trunk down to 5 or 6 inches in diameter, while pulpwood or excelsior wood can include all pieces down to 4 inches, and firewood all down to 2 inches.

How many board feet of saw timber can be cut from pine trees of various sizes?

Much depends upon the degree of care exercised, the kind of saw used, and the amounts taken from and left in the woods. The International rule (page 8) shows what can be sawed from logs with a circular saw cutting a ¼-inch kerf, all the usable lumber being taken. This rule, applied to shortleaf pine trees, shows not what is now being cut by wasteful methods but what should be taken to meet the present conditions of scarcity and high price of lumber.

TABLE 4.—*Saw timber contained in shortleaf pine trees of various sizes, if cut and utilized closely. (Cut with circular saw—scaled by the International log rule)*

Diameter of trees outside the bark at breast height, or 4½ feet above ground (inches)	Number of 16-foot logs in the tree (to a 5-inch top diameter)					
	1	2	3	4	5	6
	Board feet in the tree					
6	14	20	25	---------	---------	---------
7	16	27	40	---------	---------	---------
8	18	34	54	74	---------	---------
9	20	41	69	96	---------	---------
10	23	48	84	119	157	---------
11	24	56	101	142	189	---------
12	26	63	118	168	223	---------
13	28	71	135	195	258	---------
14	30	80	153	224	296	---------
15	32	88	171	253	337	---------
16	33	97	190	284	378	471
17	35	106	211	317	424	527
18	37	116	232	352	472	588
19	39	127	255	390	523	654
20	40	137	281	430	578	724
21	42	148	308	473	634	796
22	43	160	337	517	695	873
23	---------	173	369	563	758	954
24	---------	---------	397	611	825	1, 038

To estimate the contents of a tree, the diameter outside the bark (at breast height, or 4½ feet above the ground) and the number of 16-foot cuts are ascertained. (Fig. 5.) For example, a tree measuring 16 inches in diameter (outside the bark at breast height) and having three 16-foot log lengths will cut out about 190 board feet, as shown by Table 4.

Various kinds of tree-scale sticks, or "cruising" sticks, are coming into use. They are used to measure the diameter and the height, or the number of logs, in a tree. One is known as the Biltmore stick. Some of the sticks also show for trees of different diameters and number of 16-foot cuts, the number of board feet of saw timber that can be cut out. (Fig. 6.) Information as to sources of tree-scale and log-scale sticks and their use can be obtained from your State forestry department, the extension service of your State college of agriculture, or the Forest Service, United States Department of Agriculture.

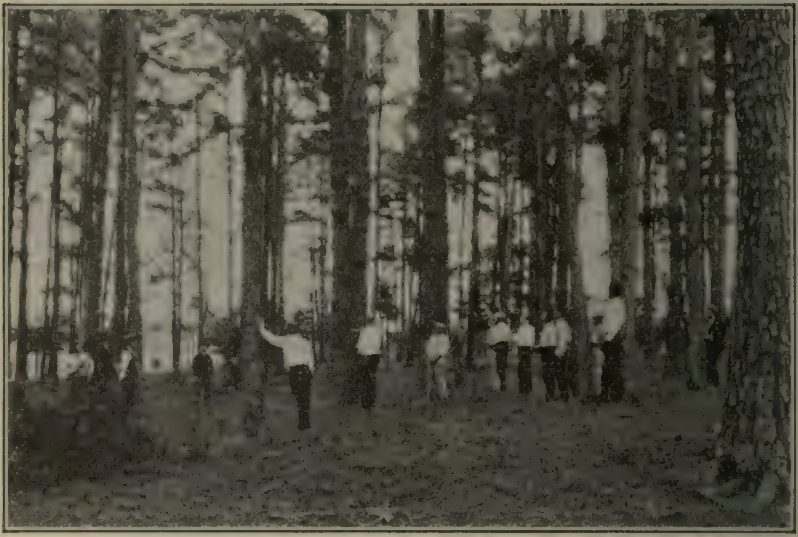
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FIGURE 5.—With a handy tree-scale stick the diameter of a tree (at breast height) is being measured. The same stick has a scale for measuring the height, or number of 16-foot log cuts, and shows also the number of board feet in the tree

TIMBER PRODUCTION PER ACRE

Is it possible to predict the amount of timber an acre will grow?

Many stands of shortleaf pine of known ages have been studied and measured to find out how much timber they will yield per acre. In this the forester deals with fully stocked stands, or those which have no blanks or spots without trees. The quantity of timber is measured in the standing trees, either in cords, crossties, or lumber. With the figures so obtained it is possible to predict the rate of growth and the quantity of timber there should be on an acre at different ages.

How many cords of wood will an acre of shortleaf pine produce? A fully stocked stand of shortleaf pine 25 years old on poor land should cut out per acre about 15 cords (with the bark on), on average land about 31 cords, and on good land about 42.5 cords. (Table 5.) The average growth is thus a little over a cord a year. In peeled wood, such as is often wanted for paper pulp and excelsior, it will be seen in Table 5 that an acre of average land will produce just about a cord a year in stands between the ages of 25 and 65 years; also the highest average rate of production of cordwood comes when the trees are between 40 and 50 years old.

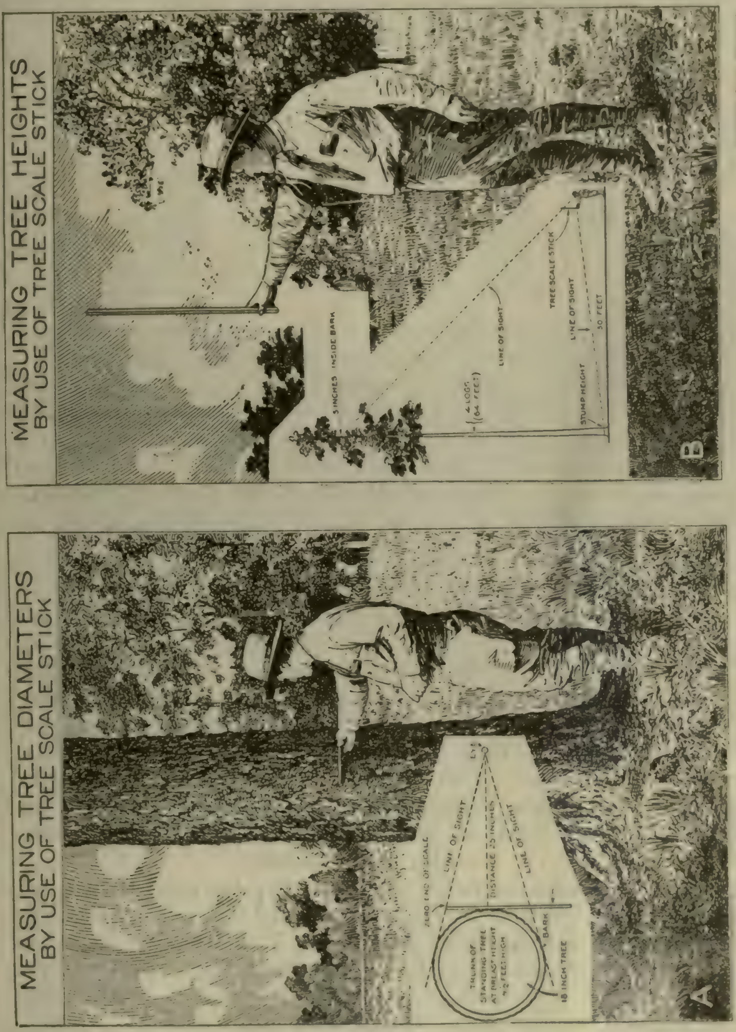

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FIGURE 6.—Estimating the saw timber in a pine tree by the use of a tree-scale or cruiser's stick: A, If the stick is held horizontally against the trunk of the tree at a specified distance from the eye, the observer is able to read directly the diameter of the tree outside the bark. The standard is called the "breast-high" diameter and is taken at a height of 4½ feet above the average level of the ground. B, The stick is graduated so that, when held a specified distance from the eye of the observer who stands a specified distance from the tree, the observer can read the number of 16-foot-log lengths in the tree. The principle is that of two similar triangles

TABLE 5.—*Cordwood yield per acre of shortleaf pine stands of different ages (fully stocked stands, or about maximum yield)*

[Includes the wood from all trees 4 inches and over in diameter]

Age of trees	Wood with bark			Peeled wood		
	On good land	On average land	On poor land	On good land	On average land	On poor land
Years	*Cords*	*Cords*	*Cords*	*Cords*	*Cords*	*Cords*
15	15.0	----------	----------	12.0	----------	----------
20	29.5	18.5	----------	24.0	14.5	----------
25	42.5	31.0	15.0	35.0	25.0	12.0
30	54.0	41.0	23.0	45.0	33.5	18.5
35	64.0	49.0	30.0	54.5	40.5	24.5
40	73.0	56.0	33.0	62.5	47.0	29.0
45	80.5	61.5	39.5	69.0	51.5	32.5
50	87.0	66.0	43.0	75.5	56.0	35.5
55	93.0	70.0	45.5	80.5	59.5	38.0
60	97.5	73.0	47.5	84.5	62.5	40.0
65	103.0	76.0	49.0	88.0	65.5	41.5
70	105.0	78.5	51.0	91.5	67.5	43.0

The number of trees required to cut a cord at any given age of the stand can be easily calculated from the last column of Table 1. For example, at 30 years of age on average land, fully stocked shortleaf stands contain about 825 trees per acre. There are about 505 of the larger, or dominant trees, and about 825 trees of all sizes 4 inches and over in diameter. If the stand on average land at that age cuts about 41 cords (column 3 of Table 5), the average tree will cut out about one-twentieth of a cord, or it will require about 20 trees to make a cord.

How much saw timber will an acre of shortleaf pine produce?

The owner or the prospective buyer of timberland should know its capacity for producing timber. Fortunately, the amount of shortleaf pine timber that can be grown per acre can be predicted because of studies which have been made of many well-stocked, "well-set," or dense, stands. (Fig. 7.) The values shown in Table 6, however, are for stands that have been burned over frequently. The table shows the amount of saw timber that such stands may be expected to cut at various designated ages. The figures do not include the timber removed in previous thinnings, or the intermediate yield, often a very considerable amount.

An acre of average-grade land, well set in shortleaf pine, for example, as shown in Table 6, in 30 years should cut out an average of 6,245 board feet if all the trees measuring 7 inches and over are sawed. If the logs were scaled by the Doyle rule, and only the trees that measure 9 inches and over in diameter at breast height were counted, the timber on the acre would scale only about 750 feet. But the scale shown by the Doyle log rule is too low, and the cut would actually be much more.

Shortleaf pine, when grown in well-set or dense stands and protected from fire, should grow an average of a cord a year per acre, or from 300 to 500 board feet a year per acre.

Such well-set and protected stands on average land at ages of about 20 to 40 years should grow about 2 cords an acre yearly, or from 500 to 800 board feet.

At 40 years, a fully stocked acre of shortleaf pine on good land should cut about 30,225 board feet, an average of about 755 board feet per year; on average land 16,110 feet, or an average of about 400 board feet yearly; and on poor land about 4,525 feet, or an average yearly growth of 110 board feet. These illustrate well the wide differences in growth due to different conditions of soil and climate. For example, almost all the southern half of Arkansas would be classed as good, whereas the dry clay hills of the upper parts of North Carolina, South Carolina, and Georgia would be average, and the firmest soils poor in quality.

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FIGURE 7.—A roadside demonstration established by a lumber company to show the growth of shortleaf pine. The signboards tell the rate of growth per acre in cords and board feet; number of trees before and after thinning and the profit in the timber as a crop.

A caution here is advisable. These figures show what would be the yield if all the trees were sound and straight. A liberal allowance for seen and unseen defects in the logs is very necessary, or the scale will be much too high.

TABLE 6.—*Lumber yield, in board feet, from 1 acre of shortleaf pine trees from fully stocked stands*

Age of trees (years)	Yield in board feet					
	Trees 7 inches and up in diameter, mill scale or actual cut			Trees 9 inches and up in diameter, by Doyle log rule		
	On good land	On average land	On poor land	On good land	On average land	On poor land
20	3, 440	225	----------	295	----------	----------
25	9, 685	2. 535	----------	1, 750	70	----------
30	17, 105	6, 245	815	4, 570	750	----------
35	24, 435	10, 860	2, 535	8, 635	2, 005	70
40	30, 225	16, 110	4, 525	12, 600	3, 985	410
45	35, 475	20, 815	6, 790	16, 435	6, 395	910
50	40, 045	24, 615	8, 960	20, 440	8, 670	1, 600
55	43, 890	27, 785	11, 220	24, 180	10, 790	2, 300
60	47, 285	30, 320	13, 485	27, 405	12, 600	3, 215
65	50, 045	32, 580	15, 565	30, 325	14, 445	4, 175
70	52, 580	34, 570	17, 195	32, 825	16, 260	5, 060

> The right use of the ax and saw and the protection of the land at all times from fire are the keys to the problem of growing timber profitably as a crop.

THINNING GROWING PINES

Why are thinnings necessary in growing pines as a crop?

As in a stand of corn or cotton, the trees in a full pine stand crowd upon each other, and the stronger trees gradually crowd out the weaker. (Fig. 8.) Too few trees on an acre result in bushy tops and knotty lumber; too many trees mean a slowing up of individual growth. There is a right number, varying with the age and location, to obtain the best growth of the largest number of trees. Thinnings are made to keep ahead of nature and reduce the number of trees, so as to obtain the maximum growth for the kind of product desired.

How should thinnings be made?

There are two ways of thinning pine stands. In a "low" thinning (fig. 9) the smaller, less vigorous, diseased, and unpromising trees are taken out. Low thinning favors the largest and best trees and more nearly keeps the timber production at its capacity. Size and quality count much in the value of the timber. The first principle is to wait until the trees to be removed have reached a merchantable size, so that the thinning may at least pay for itself, or, better still, make a profit. The material removed may be used for firewood, pulpwood, excelsior wood, or small saw timber. Shortleaf pine will be large enough for a first thinning at ages generally from 15 to 20 years. An idea of the number of trees per acre in full stands of different ages can be obtained from the last column of Table 1. This is only an approximate estimate. This method of thinning is the one that should always be used in thinning young pines.

In a "high" thinning the larger or dominant trees are cut, thus making more room for the smaller trees to expand. (Fig. 10.) The most common practice of owners is to cut out the largest trees, because they are the first to become merchantable. What happens then is the recovery of the formerly stunted trees to a normal growth. This adjustment usually requires from one to two years, during which there is some loss in the growing power of the land. Thinning by this method (of cutting out the largest trees) permits of a good money return every 10 years or so, a feature which appeals strongly to the farmer or other owner of timberland.

Does shortleaf recover its rapid growth after suppression?

Yes; it is one of the most responsive of all the important timber pines to a recovery of rapid growth following thinning. Almost immediately after the thinning of an overcrowded stand of trees, the remaining trees begin to grow at a faster rate. (Fig. 11.) On good soils the recovery is particularly rapid. This capacity helps to make shortleaf pine a good crop to grow. The increase in growth will be found recorded in the wider rings of wood, known as annual rings of growth. To a surprising degree a study of the annual rings reveals the events in the history of the stand.

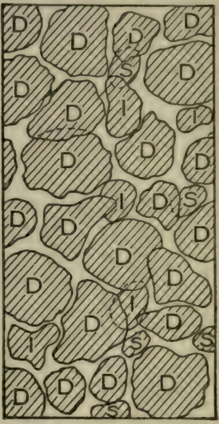


FIGURE 8. — How the tops of the trees in an unthinned overstocked stand shade the ground. In this 20-year-old stand there are about 500 dominant or thrifty trees, D; 100 intermediate or half-thrifty trees, I; and about 150 suppressed or dying trees, S, on an acre

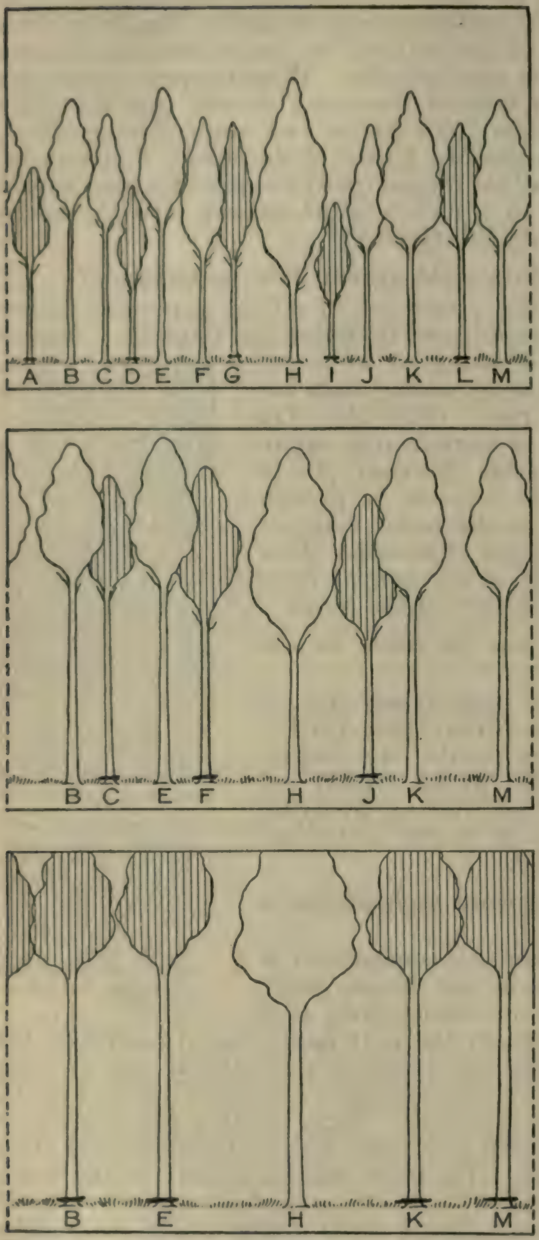
Should thinnings of pine be made in the summer?

Thinnings can be safely made at any time of the year except during the period from April to September, when certain beetles are active. These beetles are attracted to the freshly cut pine timber and often attack the near-by living trees. On page 42 will be found additional information on this subject.

What are the important wood products cut in thinning pine stands?

Pine wood is extensively in demand and is used for fuel on the farm and in the town. Every part of the tree is usable down to 2 inches in diameter. Probably the next most general market is for crossties, which, after they are creosoted, the railroads use in large numbers. (Fig. 12.) Trees often bring in a considerable part of the cash income for the farm each year. Many treating plants are now creosoting small round peeled pine posts, making them good for 10 to 20 years' use in the ground. The paper-making industry of the South in its mills from Maryland to Texas consumes thousands of cords of pine wood daily in making brown kraft paper. (Fig. 13.) The wood is bought by the standard cord of 128 cubic feet or the long cord of 160 or 180 cubic feet. It is also used in different regions for making excelsior, keg or band staves and heading, and mine timbers.

The larger or more select trees find various uses as poles, piling, and saw timber, much as does the main crop of trees, as discussed in the following paragraphs. The cutting of small-sized trees for saw



THINNING

Age of the trees, 20 years. A light thinning is to be made by cutting out the smaller, slower-growing trees. This will still keep the bigger trees slightly crowded to force them to grow upward instead of growing outward and becoming bushy

THINNING

Age of trees, 30 years. Another thinning is to be made now of the smaller, less vigorous and less promising trees

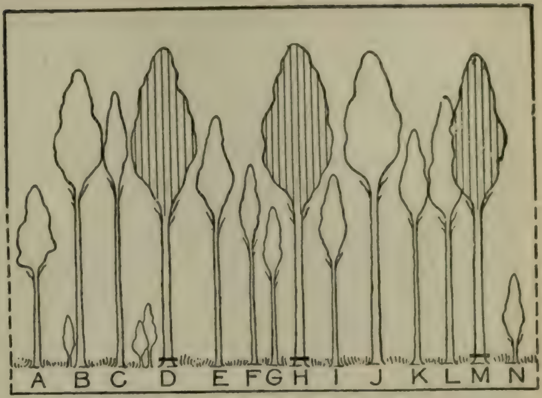
FINAL CUTTING

Age 40 years. The final cutting is made of all trees except one, H, a vigorous, bushy-topped tree, which is left to produce seed and restock the land. About three such trees are left growing on each acre until the land is well reset with young trees

FIGURE 9.—Low method of thinning or cropping. The smaller, less vigorous, and defective trees of this even-aged stand are cut out every 10 years, giving space for the stronger trees to grow. The thinnings produce small saw logs, pulpwood, posts, or firewood; the final cut produces saw timber or piling of good size, good grade, and high value. The trees to be cut are marked with vertical lines. (Note.—The letters A, B, C, etc., are used to identify the trees.)

THINNING

Appearance before logging in 1908. The largest trees are to be cut out and used or sold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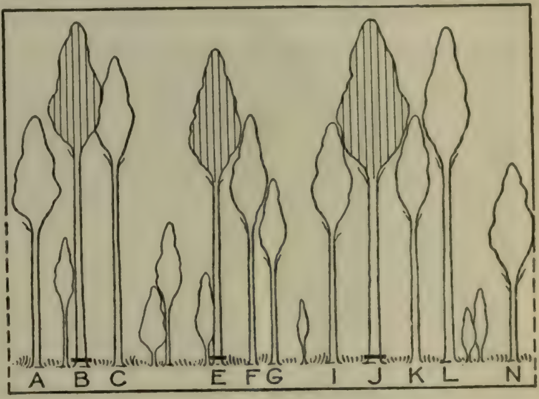
THINNING

Before logging in 1918. The growth of the trees since 1908 can readily be noticed. The trees to be cut are about the same size as those cut in the previous logging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THINNING

Before logging in 1928. As before, little trees keep coming in to fill the openings made by the cut trees. The trees cut will average between 30 and 40 years of age

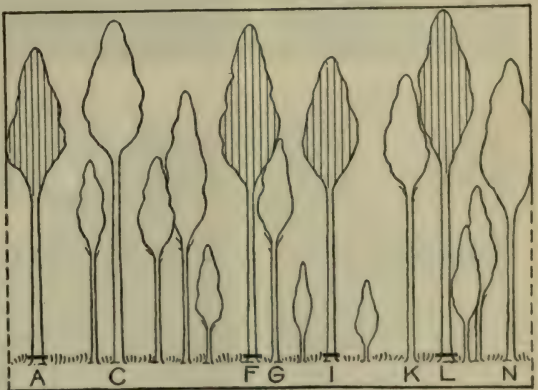

FIGURE 10.—High method of thinning or cropping. The trees are of many different ages. Every 10 years the largest trees are cut out, which gives space for others to grow to take their places. This method of cutting is common practice. The trees to be cut are marked with vertical lines. Compare with Figure 9. (Note.—The letters, A, B, C, etc., are used to identify the trees.)

logs entails a financial sacrifice that is not generally recognized. Size and quality count for much in the money value of trees.

CUTTING THE MATURE CROP

When should the main timber crop be cut?

If the stand has been successively thinned by the "low" method (fig. 9) it will mature with a relatively few trees per acre—80 to 150, depending upon the age and growth—suitable for saw timber, poles, or piling and of good size, good grade, and high value.

Many considerations should enter into a decision as to when the main crop of shortleaf pine trees should be cut and another started. The kind of product to be cut depends upon such factors as the location of the timber with reference to the best markets, prevailing prices of the various commodities, and cost of marketing the product.

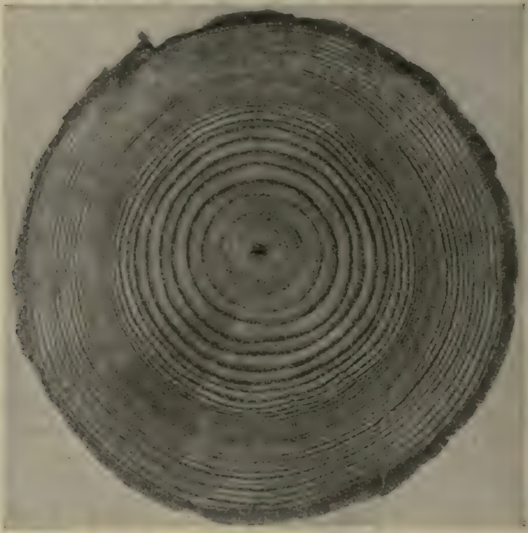

FIGURE 11.—The story of thinning out shortleaf pine trees is recorded in the annual rings of growth of this tree. As the wide rings near the center show, the young tree had plenty of space to grow. Then the trees became crowded and growth was slowed up. But shortly after the stand was thinned the tree again grew vigorously and added a good volume of wood each year

What is the right way to cut the main crop of shortleaf?

Before cutting the stand, on each acre, from three to five trees capable of producing large crops of seed should be selected to remain standing. The number will vary with the size of the trees. (Figs. 14 and 15.) A shortleaf pine seed tree should be not less than 9 inches in diameter at breast height, healthy, as young as possible, and with a vigorous, full, or limby top. Such trees have usually grown in the open or apart from others. So that they will not be cut by the sawyers, these seed trees should be spotted with white paint or whitewash, uniformly on the same side of all the trees. With these "seed trees" and with adequate protection from fire, a full stand of young growth should become established on the tract during the next two to three years after logging.

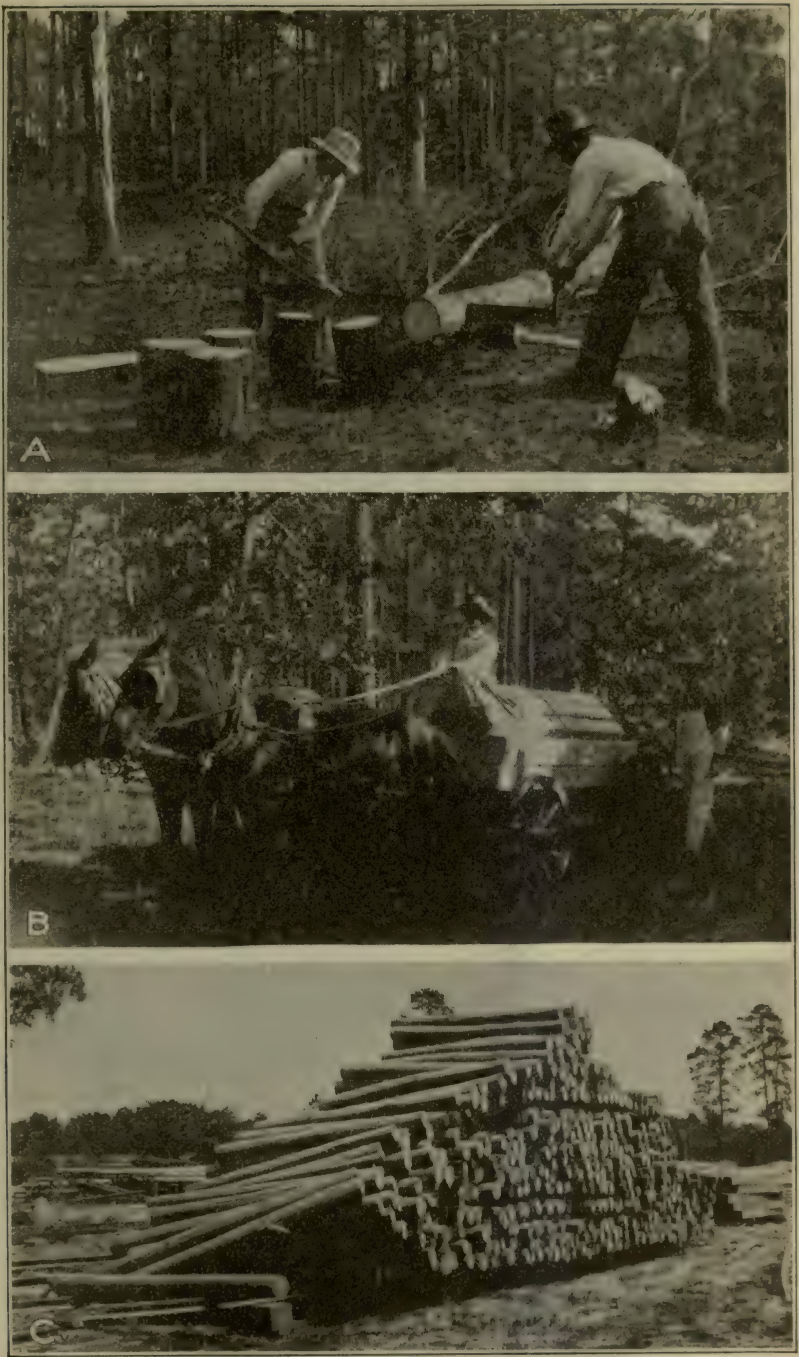

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FIGURE 12.—Products from sap pines, mostly thinnings: A, Cutting up stove wood, a product widely used; B, hauling cut crossties, an important cash crop; C, peeled pine fence posts, 3 to 5 inches in diameter, ready for creosoting

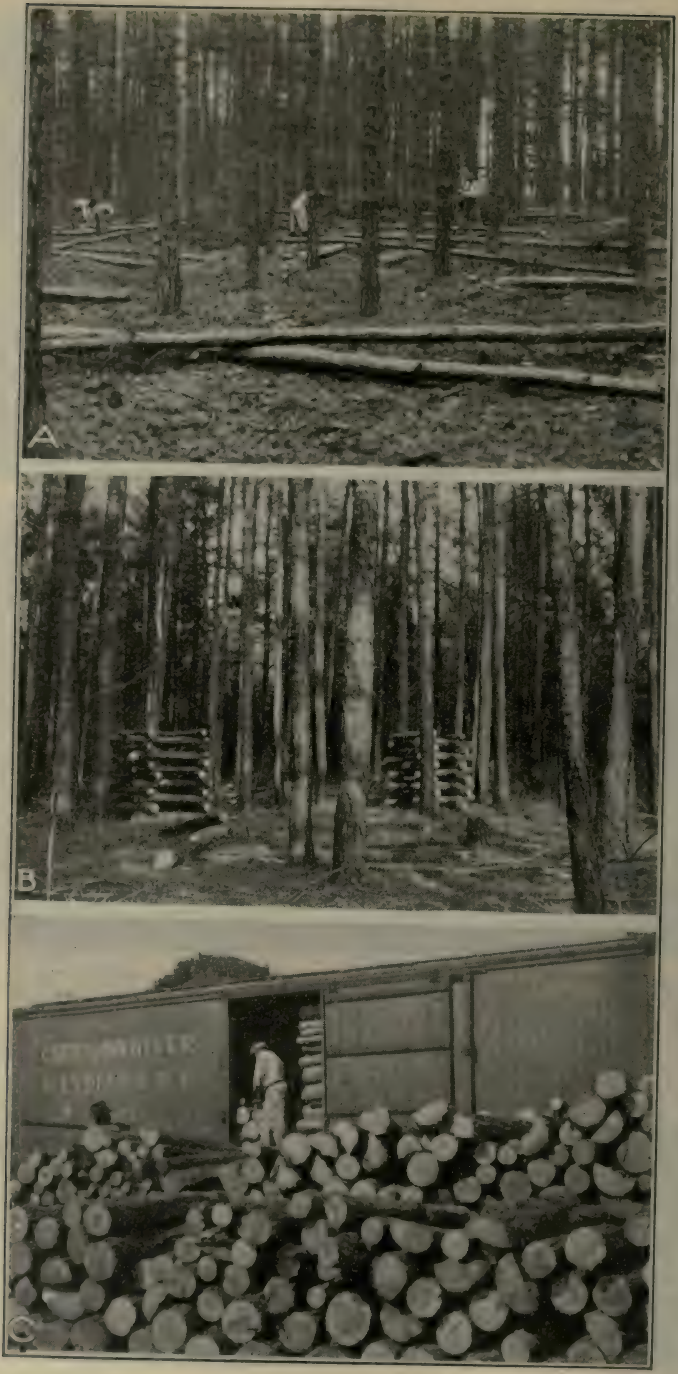

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FIGURE 13.—Many pine trees are cut and sold as pulpwood for making wrapping or kraft paper: A, Thinning the stand for pulpwood; B, pens of pulpwood piled for drying; C, loading pulpwood for shipment to paper mill

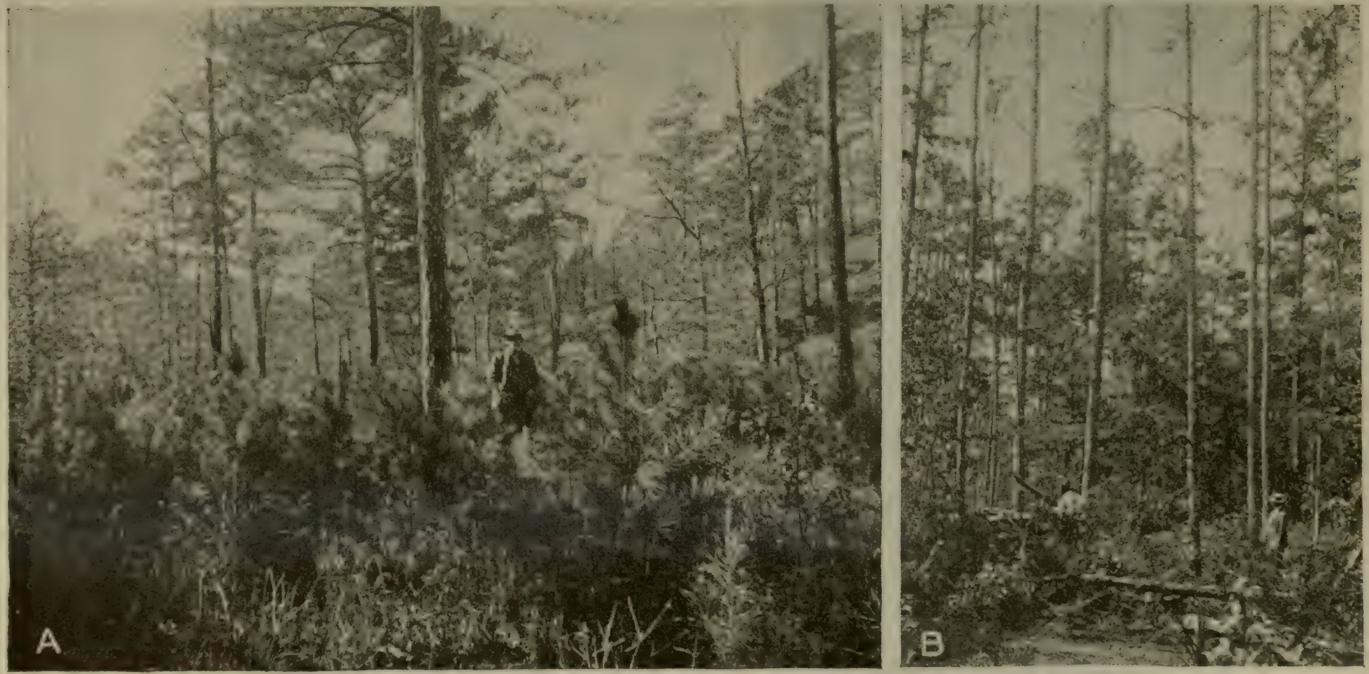

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FIGURE 14.—The crop of shortleaf pine has been cut. A, Plenty of seed-bearing trees were left, and the ground is well stocked with young trees. They are thrifty sprout trees and came up after the fire killed back the small seedling trees. B, The owner has practiced conservative cutting for many years. The largest trees have been cut for logs, and the tops are being worked up into firewood. The trees left for a later cut will grow rapidly and be very profitable for lumber besides seeding up the land

Figure 16 shows how a pine stand may be cut in successive strips so as to get some timber out every year or every 5 or 10 years, as desired. Seed trees are left at each cut, so there is a series of different-aged young pines coming on.

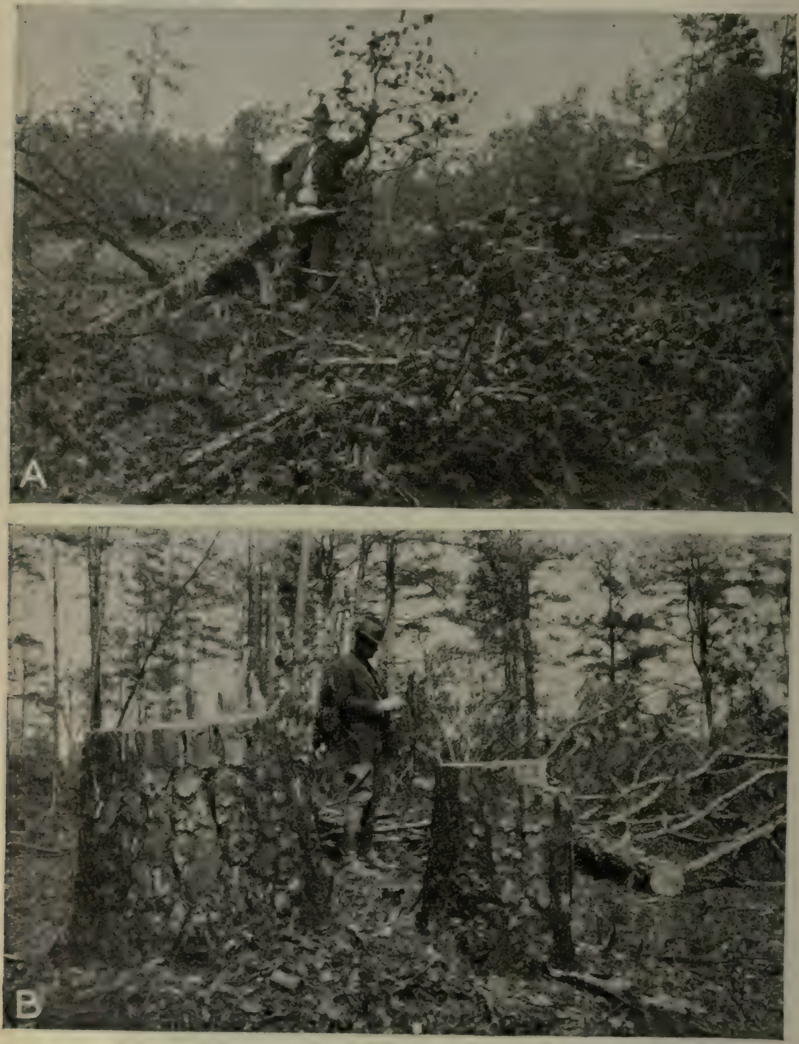

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FIGURE 15.—Wasteful logging. A, A heavy seed-bearing shortleaf pine which should have been left to restock the land. B, By wasteful cutting of high stumps, the lumberman left on 1 acre 1,080 board feet of timber. This was the best timber on the tract and worth enough to pay for the logging.

A good way to start another crop of pines without delay is to cut the trees in the fall just after a heavy crop of seed has matured. Logging makes a favorable seed bed and stirs up the seed in the soil. If the market conditions for the cut product are favorable at that season, this method of cutting all the trees and restocking the land may well be used wherever possible.

Important rules for good logging of shortleaf pine are:

Protect the woodland from fire at all times.

Leave three to five large-topped trees on each acre as seed trees. (Fig. 14.)

Cut the stumps at approximately the same height in inches as the diameter of the tree, but none higher than 12 inches.

Use the top logs to a small diameter for No. 3 saw logs, pulpwood, or firewood.

Throw each tree carefully, so as to do the least injury to the young growth.

Leave no dead tops against the trunks of any living trees, and so avoid infestation from insects or "worms."

Remember that, except in making improvement cuttings, the logging of small timber is an unprofitable business. This is because of the high cost of sawing and logging small logs and the low grades and low market value of the product.

Does it pay to hold second-growth timber and let it grow?

That can not be answered for any specific case or tract of timber. In general, however, the owner who has been conservative of his timber and not "let 'er go on the first offer," has profited. Small timber for saw logs is very unprofitable. The Doyle scale, the prevailing rule in the South, gives only a fraction of the scale that is now cut out, and the buyer pays a low rate per thousand feet for small logs. This is because felling, skidding, loading, and sawing costs are much higher per thousand board feet than for large timber and there is a big waste in slabs. Much small timber is being worked up in mills at a substantial loss to the operator, while the whole sawmill operation, because of wasteful methods and low-grade logs, pays barely enough to buy "white meat and overalls" for the workers.

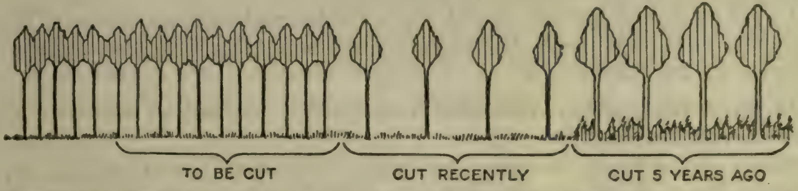

FIGURE 16.—Cutting the mature crop of trees in successive strips, one strip every 5 or 10 years. Three or four bushy-topped trees are left on each acre to reseed the land. Note that an abundance of seed fell from the trees left in logging and resulted in a complete restocking of the land with small trees. The seed trees left are no longer needed and may be cut. They have been growing rapidly under the stimulus of plenty of light and water and have made the owner a good profit

What happens when pine timberland is cut clean?

Almost everyone nowadays has seen large-sized areas of pine cut clean for firewood, pulpwood, or other product and has noticed that scarcely anything but scrub oaks, sweet gum, hickory, or sassafras came in on the land. Clean cutting of a pine stand ruins the chances of growing another valuable timber crop, except by the expensive method of planting small trees. The exception would be small areas of strips not more than 150 feet in width that are bordered by pines of seed-bearing age. It is a serious mistake to cut pinelands clean of all trees.

SELLING TIMBER

How should an owner sell timber?

A profitable way of marketing timber is to cut and haul the rough products to the mill, railroad, or other market. By rough products is meant saw logs, billets, blocks, poles, posts, or cordwood. In this way the farmer should get profitable employment for himself or his men, and his teams, and secure for himself the profits that would go to the purchaser if the timber were sold standing. In some cases other methods of selling may be best.

How may timber be sold on the stump?

In any one of four ways—by the lump or "boundary," or after the timber is cut; by log scale; by sawed-lumber scale; or by the piece, stack, or cord. If timber is to be sold by lump or by boundary on the stump, the owner should first make an accurate estimate. He should know fully what he has in the tract and what is the fair value of the timber. Selling standing timber by a mill tally of the lumber cut is one method used as the values of timber rise. A better way is to sell by an accurate log scale, such as the International, which helps toward complete use of the timber. Unscrupulous buyers are ready to take advantage of those who do not know the amount and value of their timber. Buyers are entitled to no more than a fair profit. The farmers have not been receiving their share of the value of their timber crop. Also many of the trees for which they have failed to receive pay have been wasted by carelessness in cutting.

In all cases the owner should use a timber-sale contract, specifying the scale rule to be used, the money considerations, and the necessary provisions for cutting so as to perpetuate the timber growth.

Is there any further available information on how to measure and how to market timber?

Some of the State forestry departments and State colleges of agriculture have publications on this subject. The United States Department of Agriculture, upon request, will furnish copies of Farmers' Bulletin 1210, Measuring and Marketing Farm Timber.

How much profit is there in growing shortleaf pines as a crop?

The profit will vary with the region, kind of soil, trees per acre, and handling or care. It is not difficult to arrive at an approximate estimate.

Assuming that the owner has a good stand of pines that has been kept free from fires, and that he thins the trees two or three times at intervals of 5 to 10 years, and markets the trees thinned out for pulpwood, excelsior, or firewood, and cuts and sells at present prices the final crop when the trees are 40 years old, hauling all the products to the railroad, mill, or other market, a method of finding the net profit is as follows:

PROFIT FROM 1 ACRE OF PINES GROWN AS A CROP

(The main crop cut when 40 years old)

Money returns from timber:	
20,000 board feet of saw logs at $10 per thousand delivered at railroad or mill	$200.00
25 cords of pulpwood, excelsior wood, or firewood cut (in thinnings and main crop) and delivered at $5 a cord	125.00
	325.00

Cost of growing and marketing the crop:	
Rental of land worth $10 an acre for 40 years at 6 per cent compound interest	$92.85
Taxes at 10 cents an acre plus protection against fire and care, total of 15 cents an acre yearly for 40 years, at 6 per cent compound interest	23.21
Cost of logging and hauling logs and cordwood to railroad or mill (including wages for owner and team)	117.00
	233.06
Profit on timber crop: Clear profit per acre over 40-year period of growing the crop	91.94
In addition to good wages for man and team and 6 per cent compound interest return on the investment, yearly average net profit per acre	2.30

The prevailing local figures can be substituted in the above example, which may then show a higher or a lower yearly clear profit than the $2.30 an acre, over and above good wages for man and team and a 6 per cent return on the investment. This may fairly be looked upon as a satisfactory money return on lands that will not be needed for agriculture for a generation or two.

Can shortleaf be grown profitably for firewood?

A 25-year-old stand of shortleaf pine in Burke County, N. C., was cut and sold for firewood. It had come up in an old pasture three-fourths of an acre in area. It cut 30 cords or at the rate of 40 cords per acre. This is an average growth of nearly 2 cords per acre yearly.

An account was kept of the cost of each step in the operation and of the returns. Cutting cost $1.25 per cord and hauling to market $1.25, making the total $2.50 per cord. The wood sold for $5 per cord, which brought on a basis of 40 cords per acre a total return of $200. As the cost was $100, the profit was $100 per acre. Averaging this over the period of 25 years—the age of the trees—makes an average gross profit of $4 per acre yearly. If taxes, a fair rental, and interest charge on the land were deducted, undoubtedly there would remain a good net return.

Can shortleaf pine be worked profitably for turpentine and rosin?

Under the best conditions of high market prices and closeness to a turpentine still, it is doubtful whether it ever pays to work shortleaf for gum. During a recent year of high prices operators in southern Alabama cupped shortleaf pine along with the longleaf pine trees. (Fig. 17.) The difficulty lies in the rapid checking of the flow of gum, which makes the expense of chipping relatively very high for the amount of gum obtained.

How is growing timber like a savings-bank account?

The trees are the capital; the new growth is the interest. Shortleaf pine under protection and properly thinned grows rapidly in the South and brings in good interest in dollars and cents.

If the timberlands are cut too heavily, the capital is drawn from the woods bank and little interest is obtained. If the timber is worked wisely and only the amount of the new growth, or interest, cut, the capital in the woods bank will be left untouched. This will keep the lands growing timber at the maximum rate and make the largest profit for the owner. In a nutshell, good banking practice in the growing of timber as a money crop is to use the ax and saw rightly and to keep out fires at all times.

REFORESTATION BY NATURAL SEEDING

If given a chance—that is, if an ample number of healthy seed-bearing trees are left on the land after logging, and if frequent and severe fires are prevented—shortleaf pine will fully restock the land. (Fig. 14.) It produces seed abundantly. The seed is very small (about 52,000 to the pound) and is easily blown because of the "wing" attached. If rightly handled, our shortleaf pinelands would all be well reset with pines, promising a good profit for their owners. Nature must operate under natural laws; therefore some mature seed-bearing trees should always be left standing.

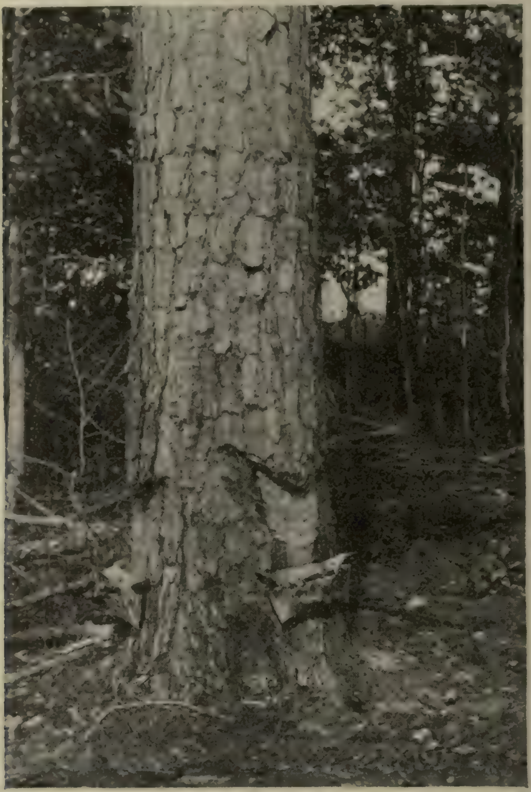

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FIGURE 17.—It is unprofitable at average current prices of naval stores to work shortleaf pine for gum. This operator was working all the shortleaf and longleaf trees on his farm-leased permit

Where do the seed come from?

From the cones, or burs, which mature and open in the fall. Each cone scale bears two seeds in hollows, or pockets, at its base, which may easily be seen upon examining an open bur. The small scales near the tip and base of the bur commonly do not bear fertile seed. The burs start from very small female flowers that have been fertilized by pollen from the male flowers, and they require two seasons to mature. The pines all bear male and female flowers separately but both kinds on the same tree.

How often does a tree produce seed?

Not every year, but usually a heavy crop of seed about every third year, with often one and sometimes two light crops during the interval.

When do the seeds of shortleaf pine sprout?

Commonly in the spring, after lying on the ground over winter. Incidentally considerable loss of seed is sure to occur because squirrels, mice, birds, and insects eat them for food.

Are abandoned fields reseeding to shortleaf pines?

Yes; provided the field happens to have a goodly number of mature seed-bearing trees around it. Before timber became of much value—some 10 to 25 years ago—around or near fields there generally stood numbers of forest pines. These produced seed abundantly and started the dense or well-stocked stands of old-field pines now coming into value. (Fig. 18.)

Unfortunately, the greater number of the fields abandoned during the last 10 to 25 years have only a scattering of young pines. Possibly good stands of trees occur only over small portions of the fields near the margin of woods. Fields with scattering "bush" pines promise no crop except a small amount of very low-grade saw timber, pulpwood, or firewood.

REFORESTATION BY SPROUTING

Does shortleaf sprout?

Yes. Shortleaf pine sprouts vigorously and successfully to grow another crop of trees. Of all the important commercial pines in the United States, shortleaf alone has the power of complete reproduction by sprouting. (Fig. 19.) This very unusual property in large measure accounts for the splendid way in which shortleaf pine comes back as it does after repeated hot fires in the dry uplands, where it finds its natural home.

What is its capacity for sprouting?

Over large sections of the South where burning has long been the custom, practically all of the second-growth shortleaf pine trees are sprouts.

Fire and cutting are the chief causes for sprouting. A tree can sprout after repeated burnings or cuttings. (Fig. 20.) Three successive generations of sprouting have been identified and studied by the writer. The vigor of growth appeared to be as strong in the third as in the first generation.

After a tree reaches a size of about 6 to 8 inches in diameter, or an age of 10 to 18 years, depending upon the quality of the soil, it loses its power to sprout successfully. Under frequent and severe burning the young trees lose much of their vigor for successful sprouting.

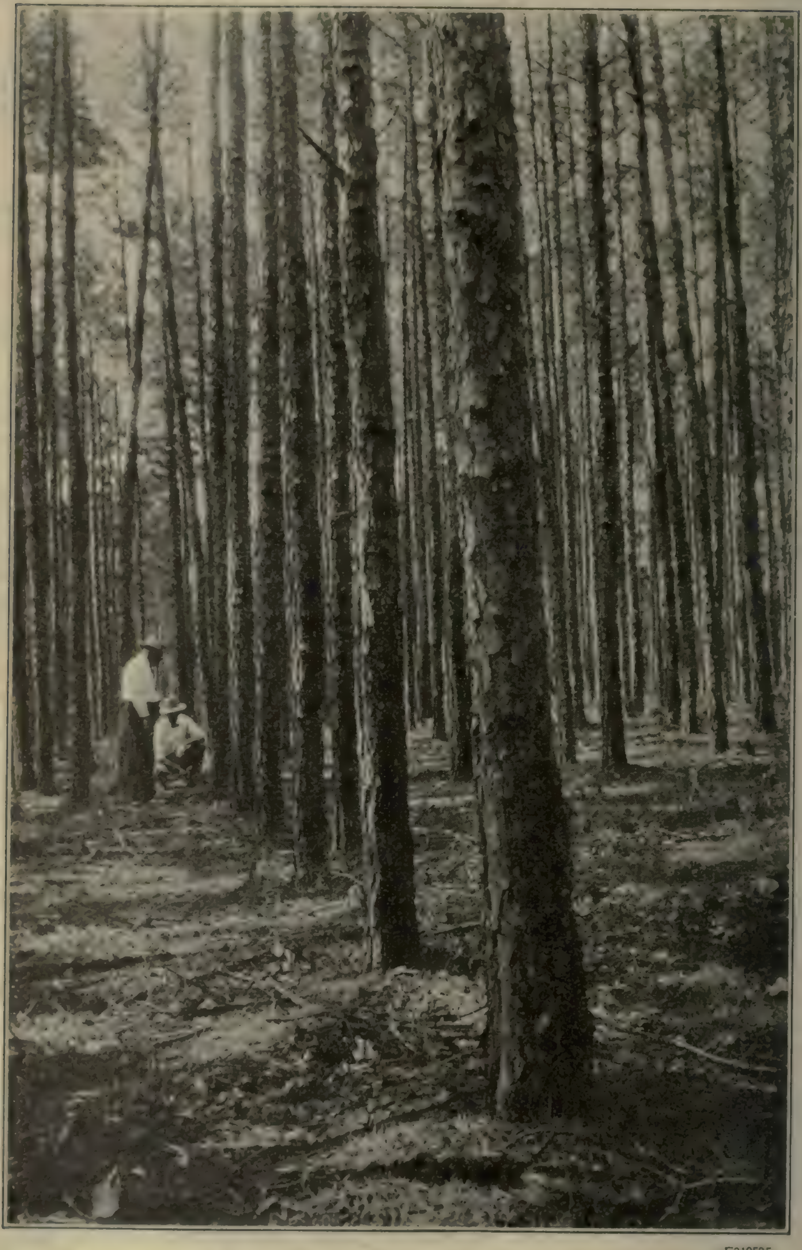
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FIGURE 18.—Shortleaf pine trees that sprung from seed blown and collected in a furrow in an abandoned cotton field

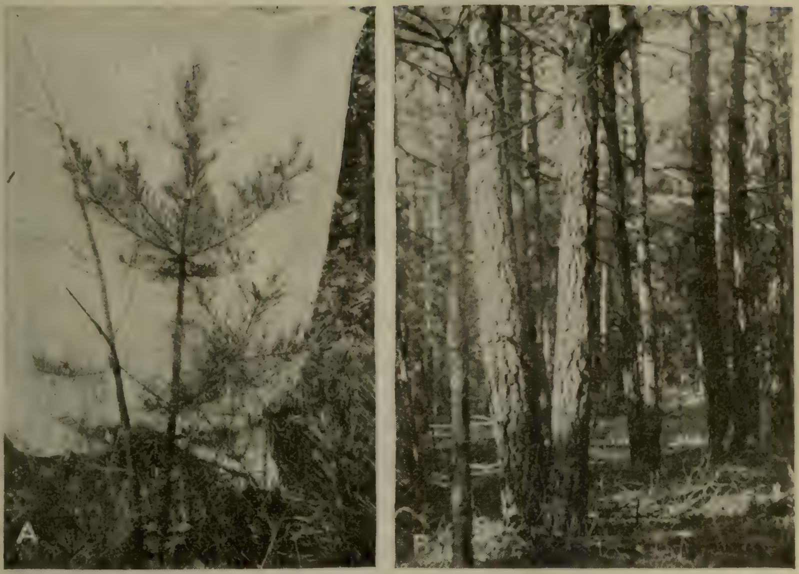

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FIGURE 19.—Shortleaf pine comes back successfully by sprouting after being cut or burned when young: A, A vigorous 2-year-old sprout and the parent sapling killed back by fire (northern Georgia); B, Sometimes two sprouts grow to form trees (Arkansas)

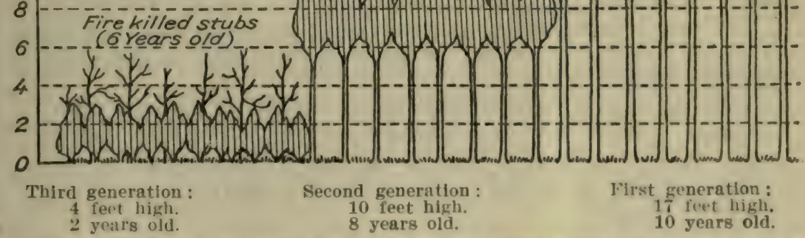

FIGURE 20.—Three generations of shortleaf pine sprout trees growing vigorously. The parent trees were killed back by successive fires. The fires came from the left-hand side, and burned the dense stands as far as the ground had become dry

What causes the sprouting?

Just below the surface of the ground, where the stem and root system of the young tree meet, is a double crook, or knee, forming a short horizontal section at the top of the taproot. After fire or cutting kills back the tree above the ground, the small reddish-gray buds (adventitious buds), which occur on this horizontal portion of the stem and root, begin to develop into sprouts. If the stem is killed or cut in midsummer the succeeding sprouts are numerous and make a weak growth; if in winter, they are few and one or two (rarely three) grow vigorously upward, while the others spread horizontally and gradually die. In one season the sprout tree grows from 1 to 2 feet in height, or as much as a seedling tree grows in two to four years.

REFORESTATION BY PLANTING SMALL TREES

Pines grow from seed and may be set out like cabbage or tobacco plants.

On certain lands that have become denuded of pines, or on abandoned fields where no seed-bearing pines are near by, it is often good business to start pines by setting out small trees grown in nursery beds.

Is the direct seeding of land advisable?

Because of the high cost of pine seed and the usual heavy losses of seed sown on lands which it is desired to reforest, it is not practical at present to start young pines by direct seeding. However, improved methods may be found in the future for treating, or poisoning the seed, and for sowing it, which will make direct seeding a practicable method.

Thousands of worn-out fields in the Southern States are washing badly and growing up to briars, plum bushes, sassafras, or scattered bush pines. (Fig. 21.) They are practically idle and are not earning their taxes.

Idle lands mean a lowered income to the owner and to the county or State. This means a higher tax rate on the remaining productive lands.

If these idle lands were planted with pines, they would become a valuable asset to their owners and to the community and State.

Get in touch with your State forester at the State capital, your extension forester at the State college of agriculture, or your county agent, if you wish to put your vacant lands to work or make your timberlands most profitable.

How can shortleaf pine seedlings be obtained?

They may be dug up in abandoned fields or grown in prepared nursery beds from seeds or purchased from State or private nurseries. A number of the State forestry departments in the shortleaf pine region are growing pine seedlings for distribution to the public at nominal prices.

Small trees grown in the woods are slow growing and when 4 to 8 inches high may be from 3 to 5 years old. Such trees should not be used for planting, as they continue to make slow growth. The best are stocky or bushy seedlings 1 to 2 years old (or 3 years old in the more northern part of the tree range and if not over 8 inches in height) grown in recently abandoned fields or in loose soil along stream washes. The root system should be much branched and well developed.

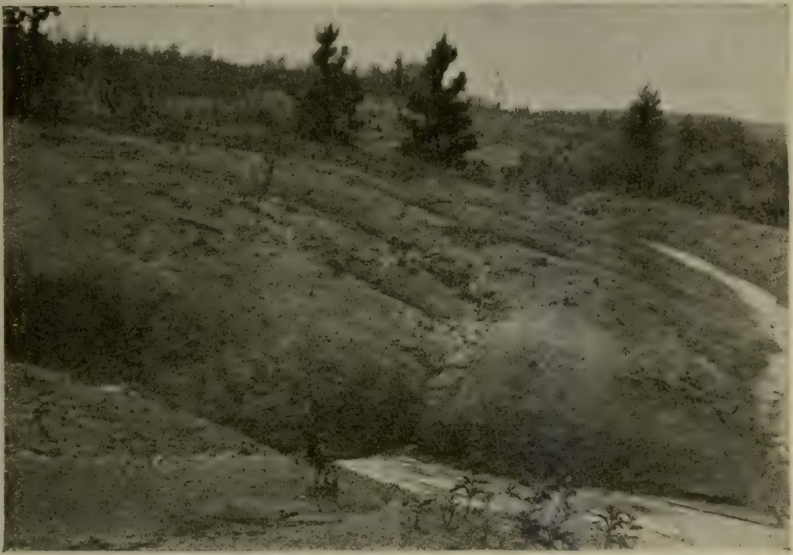

FIGURE 21.—Ten years of soil washing on an abandoned hillside field, in the piedmont section of Georgia, showing the old terrace on the right. Pines, if started, would grow well, as shown by the vigorous saplings

How can seedlings be grown in nursery beds?

Generally it is far better to grow shortleaf pine seedlings in nursery beds than to attempt to dig them in old fields. Dense patches of 2-year-old seedlings growing in loose soil and having the right sort of development are rarely found.

The nursery bed may well consist of a plot of ground 4 by 12 feet, or 4 by 16 feet or even longer, depending upon the size of the operations. It may be flush with the general level or slightly raised and confined or protected by 1 by 4 inch boards sunk 2 inches in the soil. The soil surface if raised much above the level is likely to dry out rapidly.

An acid soil gives the best results, as damping-off fungi are common and thrive in alkali or neutral soils. Old gardens should be avoided, unless fresh woods dirt or river silt (which are both acid) is brought in and used. The beds should preferably be located near the house or barn and always where supplies of water can be given during dry spells. A well-drained, sunny location should be chosen for pine seed beds.

In the early spring one-quarter pound of shortleaf pine seed, or about 13,000 seed, should be sown broadcast evenly over the well-worked soil in each 4 by 12 foot bed. The soil should, if possible, be worked first the fall before the sowing and again in the spring. Four 4 by 12 foot beds will be needed for a pound of seed. After being sown the seeds are pressed into the soil by a roller, plank, or spade, and covered by a layer of burlap or a thin sprinkling of fine sand, or better than sand, vegetable humus or fine leaf litter. It should be as free as possible from weed seed. The bed should be watched closely, and carefully watered in case of hot, dry weather. This period during the germination of the seed is critical, and the supply of moisture means either failure or success. If a burlap cover is used, it should be removed as soon as germination is visible, since the seedlings lift up the seed coats, much as do cucumbers and watermelons.

At the end of the season, the seedlings should be from 4 to 6 inches high and satisfactory for planting in favorable soil in the more southern States. However, if the lands to be reforested are dry or otherwise unfavorable or located in the mountains or more northern States, it will pay to use larger seedlings, grown for two seasons in the nursery beds or for one season there and one season in a transplant bed. The sturdiest and hardiest little trees for planting are those that have been transplanted from the seed beds at the end of one year, set about 2 inches apart in rows spaced 6 inches apart in beds, and allowed to grow for one year. They have the advantage of large root development.

How should nursery beds be protected and cared for?

Generally no wire screening is necessary for protection against birds and rodents, during the two or three weeks' period of germination, especially if the seeds are covered with a layer of burlap or gunny sack. If necessary, the sides and top of the bed should be covered with ½-inch mesh wire builders' cloth fastened over a light framing, as shown in Figure 22.

From the start all weeds should be pulled out when small; otherwise they will injure the pines when growing and when being pulled out.

A dense stand of pines of about 5,000 to 6,000 to the bed, or a few more than 100 per square foot, will require much soil moisture during hot weather; therefore the bed should be watered during dry spells. A thorough watering once in two or three days is far better than a light surface wetting every day. Furthermore, it requires less time.

During the summer the pine seedlings will require partial shade from the sun (fig. 22), especially if good watering arrangements are not provided.

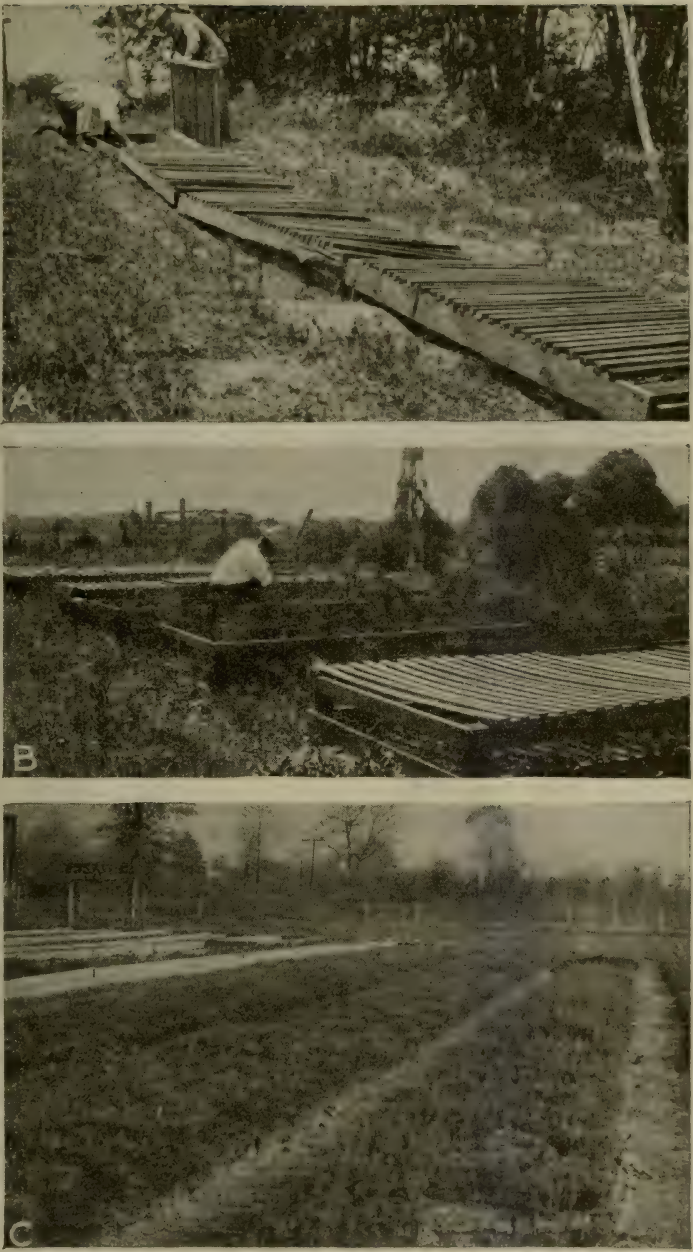

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FIGURE 22.—Various types of nursery beds for growing pine seedlings. A good size is 4 by 12 feet. Shade should be provided, also good watering facilities in the summer time. A, Crude type of bed with 1 by 8 boards set about 2 inches deep in the soil. The lath shade frames should be of light construction. B, A nursery of the Southern Forest Experiment Station. C, Where water is used plentifully in dry weather, shading may be unnecessary

Each bed should be protected with two sections of lath screen, each 4 by 6 feet. The shade frames can be made of 1 by 2 inch strips, with proper bracing, covered with laths spaced about 1½ inches apart. About 50 laths will be required for the two sections. This construction will afford one-half shade. The frames should be supported at a height of about 18 inches above the ground by three crossbars resting on stakes. The frames should be strong enough to stand necessary handling. If water is applied freely during all dry periods, the shading is unnecessary.

Moles sometimes cause trouble and may be kept out by encircling the bed with a narrow trench filled with lime or by sinking a strip of half-inch wire mesh to a depth of 1 foot around the bed.

What should be done to combat damping off and weeds in nursery beds?

Damping-off fungi sometimes cause serious injury and loss during the first two or three weeks after germination. They attack the tender roots and later the stem at the surface of the ground, causing wilting and quick death. The damping-off disease is likely to occur during hot, moist weather, at which time it spreads rapidly. The remedy is, if possible, to dry out the soil in the bed by giving it better ventilation. A thin layer of dry sand sprinkled over the surface of the soil is said to be helpful. Lime should never be used. The spores of this fungus are present in almost all old gardens and cold-frame beds; it is therefore advisable to make the bed in new soil or to bring such soil in for use in the bed.

Tests are being made of various chemicals for killing out the damping-off fungi, and also weeds. Different soils appear to require different treatments. Further information can be obtained by writing to the Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C.

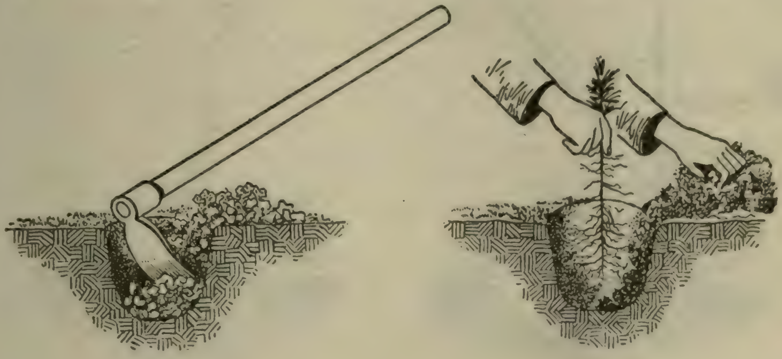
When is the best time to plant pine seedlings?

In the early spring, before the buds begin to swell, the conditions are most favorable for planting pine seedlings. Late-fall planting may give good results if the season happens to be wet and the winter mild, but much injury may be expected during a dry fall and during a severe winter, because of frequent or hard freezing and the resulting upheaval of the soil. If planted in the late spring after the new growth has started pine seedlings are very likely to die.

What are the important directions for planting pine seedlings?

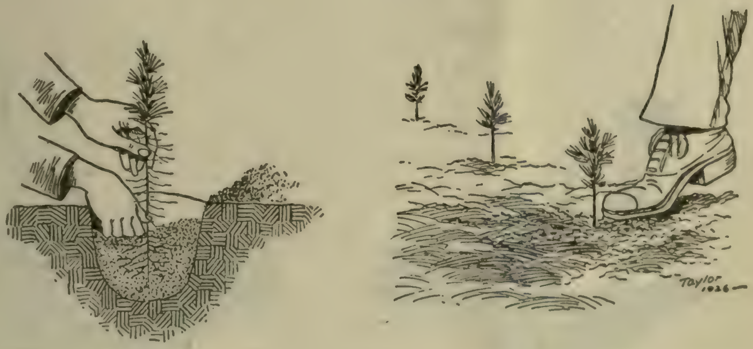
The seedlings should be carefully dug and lifted from the nursery bed so as not to damage unnecessarily the fine rootlets. All underdeveloped seedlings should be thrown away, since it is an expensive mistake to plant spindling or sickly small trees. The taproot, if over 6 inches long, should be pruned back with a sharp knife. The roots at all times must be kept wet; hence the seedlings should at once be placed in tubs or buckets with water or wrapped in wet moss or gunny sack. If not wanted at once for planting, they should be heeled in, in fresh soil, always in a cool, shaded place, and the soil never allowed to dry out. The leaves should be left exposed freely to the air but never to direct sunlight.

A good method of planting pines in open ground is to run furrows 6 feet apart to break up the soil and mark off the land. The trees are then set in the furrow about every 6 feet. This requires 1,210 trees per acre. The more fully the ground is broken up in the furrow or furrows in advance of planting the more rapid will the growth be. Weed competition is also checked. It will be found impracticable to do more than simple inexpensive preparation of the soil in starting a young forest.



(A) DIG HOLE LARGE ENOUGH TO SPREAD THE ROOTS

(B) PARTLY FILL THE HOLE AND PACK THE SOIL

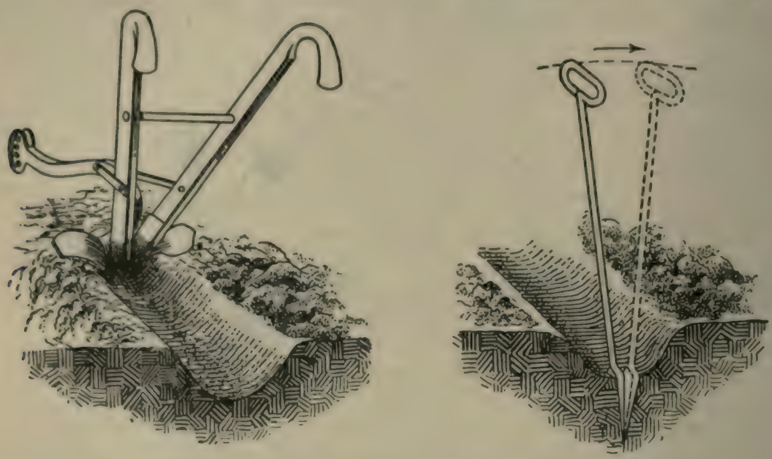


(C) PACK THE SOIL TWICE BEFORE FILLING THE HOLE

(D) FIRM THE SOIL WITH THE SOLE OF SHOE. SCRAPE LOOSE SOIL OR LITTER OVER SURFACE

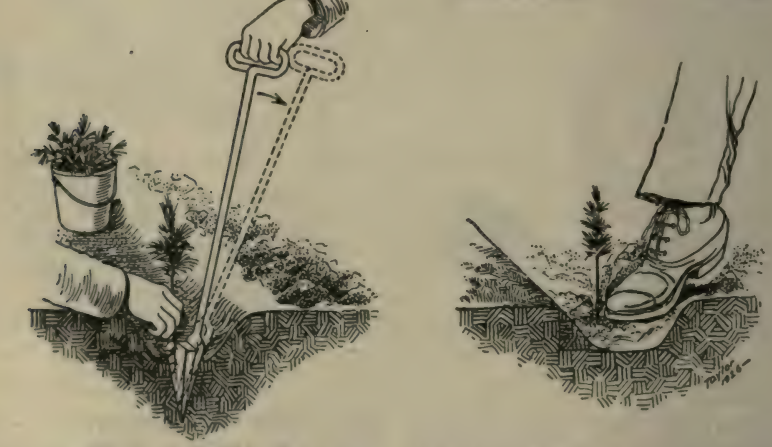
FIGURE 23.—How to plant small pines with a mattock or grub hoe. The land may be furrowed before planting and a dibble (fig. 24, B) may be used instead of a mattock

Some essential points in good planting of small trees are as follows: A hole is opened only a little larger than is needed to spread out the roots. Holes are often dug too large and trees left too loosely set in the ground. A mattock (mattax) or a grubbing hoe is a good tool for use in planting. (Fig. 23.) The seedling tree is set with the roots spread in as natural a position as possible, the taproot being kept always straight down. Soil is then scraped in about the tree, which should be set just a little deeper than it grew in the nursery bed. The soil is then firmed, and the filling-in and tamping process is usually repeated in order to avoid rapid drying out. The sole of the shoe will be found suitable for this purpose. A little straw or loose soil scraped about the tree will act favorably as a mulch against rapid drying. The trees to be planted should be carried about in



(A) PLOW FURROWS

(B) OPEN A SLIT IN THE FURROW WITH A DIBBLE (CROSSWISE AS SHOWN) OR PARALLEL WITH FURROW



(C) HOLD TREE IN THE SLIT CLOSE IT AT THE BASE

(D) CLOSE TOP OF SECOND SLIT WITH THE FOOT

FIGURE 24.—How to use a dibble in planting small pines. The dibble opens a narrow slit in the soil in which the seeding pine is planted. Then the soil is pushed up against the roots. A mattock (fig. 23) may be used in planting in furrows instead of the dibble

buckets containing water and the roots should be kept in water or preferably in a clay puddle.

In loose open soil a planting iron, or dibble, may be used advantageously. (Figs. 24, 25, and 26.) It is a straight, thin blade on a handle and is used to open a slit and to close it after the little tree has been set in the slit. (Fig. 24 C.) In loose soil two men or a man and boy should set an average of about 2,000 trees per day with a dibble, or nearly twice as many as by using a mattock in firm soil.

Advantage should be taken of favorable weather. Cloudy weather following rains affords ideal conditions. After planting, no further attention will pay, except protecting the trees at all times from fire and hogs or other injurious livestock.

No livestock should be permitted to run over land set in pines for at least the first five years, and fire should be excluded at all times. (Fig. 29.) Watering or cultivating the trees in a forest plantation is impracticable from a financial standpoint. The case is different where a few trees are set out for ornamental purposes.

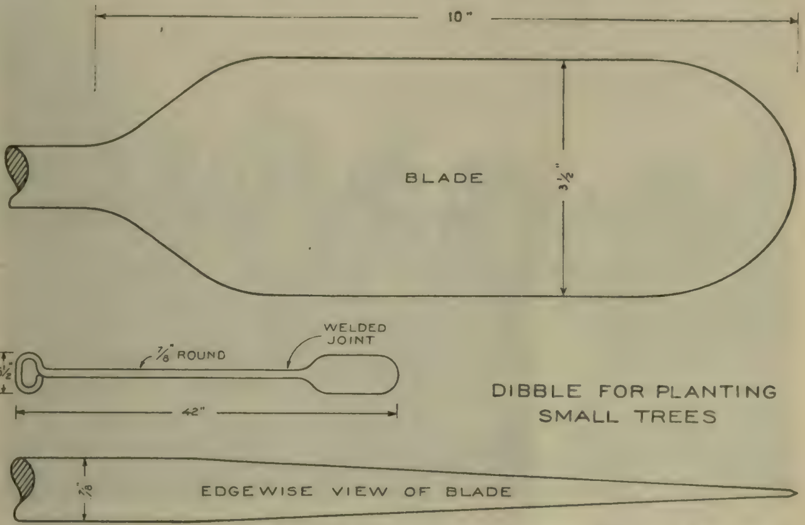


FIGURE 25.—The dibble is much used for planting small seedling pines. It has a thin, flat steel blade attached to a steel or, less serviceably, a wooden handle

In a forest plantation the loss up to 15 per cent of the total number of trees set out is not an uncommon experience. Among the causes are the use of poor grade of trees and drought at the time of planting or soon after. If any considerable loss occurs it is good practice to reset the blank places the next spring or a year later.

Where can shortleaf pine seed be obtained?

It may be collected from trees or purchased from dealers. So far as possible seed should be obtained in the same locality in which the young trees are to be planted.

Pine seed is most economically obtained from trees felled in logging. Any time after the burs begin to turn brown in the fall the seed is ripe and may be collected. The burs should be pulled off the tops, collected in burlap or gunny sacks and later spread out to dry on a tight floor or on canvas in the sun. In drying weather they will open in a few days, and if they are then beaten or stirred the seeds will fall out. The wings cling tightly to the seed and in ordinary practice no attempt is made to break them from the seed. Sometimes the seed may be quickly obtained directly from the felled tree tops by beating the open burs with a stick while holding a sack, tub, or bucket under them. About 2,000 unopened burs make a bushel.

In favorable seasons where logging is in progress shortleaf pine seed may be collected for as low as $2 a pound, but it often costs from $3 to $4. There are about 52,000 winged, clean seed in a pound. Commercial dealers make an additional charge for handling and to pay for some inevitable loss incident to keeping fresh stock on hand. The seed commonly retails at $6 to $8 per pound. Thus far the demand for pine seed has not been strong enough to result in much competition or low prices. At intervals of every two to three years any specified tract or stand of pines will usually produce a heavy seed crop. Inquiries as to where shortleaf pine seed may be obtained and a list of commercial dealers, should be directed to the State forester, the extension forester at the State agricultural college, or the Forest Service, Washington, D. C. In buying pine seed fresh stock should always be specified. Pine seed average only about 60 to 70 per cent of good seed, varying more widely in good or bad seasons.

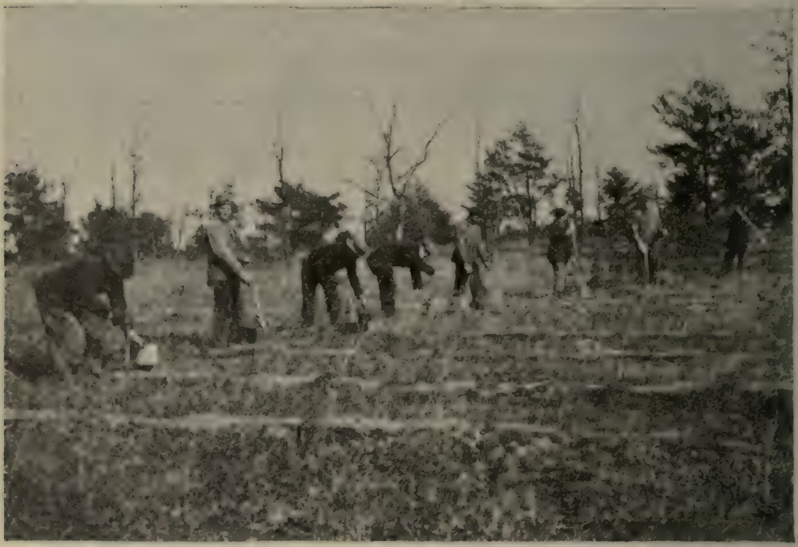

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FIGURE 26.—Planting pines in furrows in open sandy land by the use of a planting tool, or spud, known as a dibble. This makes possible the rapid planting of small trees in loose soil

What does it cost to plant an acre of pines?

Much depends upon the scale of the operations and the condition of the soil. It is assumed that the trees are set 6 by 6 feet apart, or 1,210 per acre. If the seedlings are grown in nursery beds at home, the actual expense may be no more than the cost of the seed, from 20 to 40 cents, and the value of the time put in in growing and setting out the little trees. Two men, or a man and a boy, working with a mattock in average soil, should set an acre of pines (1,210) in a day. In loose fresh soil the two workers, using a dibble, should be able to plant 2,000 trees. These estimates are for open, smooth ground, and must be reduced by one-fourth to one-half in rough hilly land. Furrowing the ground would add another item of expense. These figures will indicate the probable cost of reforesting land. Large operations are cheaper proportionately than small ones.

Are there any planted shortleaf pine stands?

Yes. Young planted stands up to 5 to 8 years of age are to be found in many of the Southern States. (Fig. 27.) In Spalding County, Ga., and in Alamance County, N. C., are excellent stands of a few acres of shortleaf pine from 35 to 40 years old. (Fig. 28.) Near Biltmore, N. C., are many acres of shortleaf pine planted from 1896 to 1907, both in pure stands (shortleaf pine only) and in mixture with forest trees of other kinds. Younger plantations are to be found in several other States.

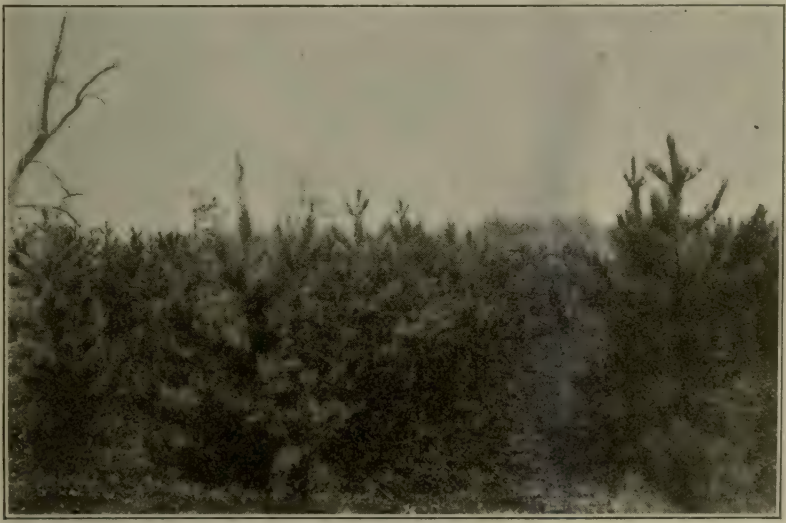
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FIGURE 27.—Five-year-old shortleaf pine planted as 1-year-old nursery-grown seedlings in a worn-out field in the piedmont clay soil region, Iredell County, N. C.

PROTECTION OF THE GROWING CROP

Is burning the woods injurious?

The damage and loss to forest growth caused by fire exceeds the combined effect of all other injurious agencies. (Fig. 29.) At the same time, this cause of injury is chiefly man-made and of all the sources of injury can be most readily controlled.

The yearly burning of the woods, extensively practiced in some parts of the natural home of shortleaf pine, has been done with little

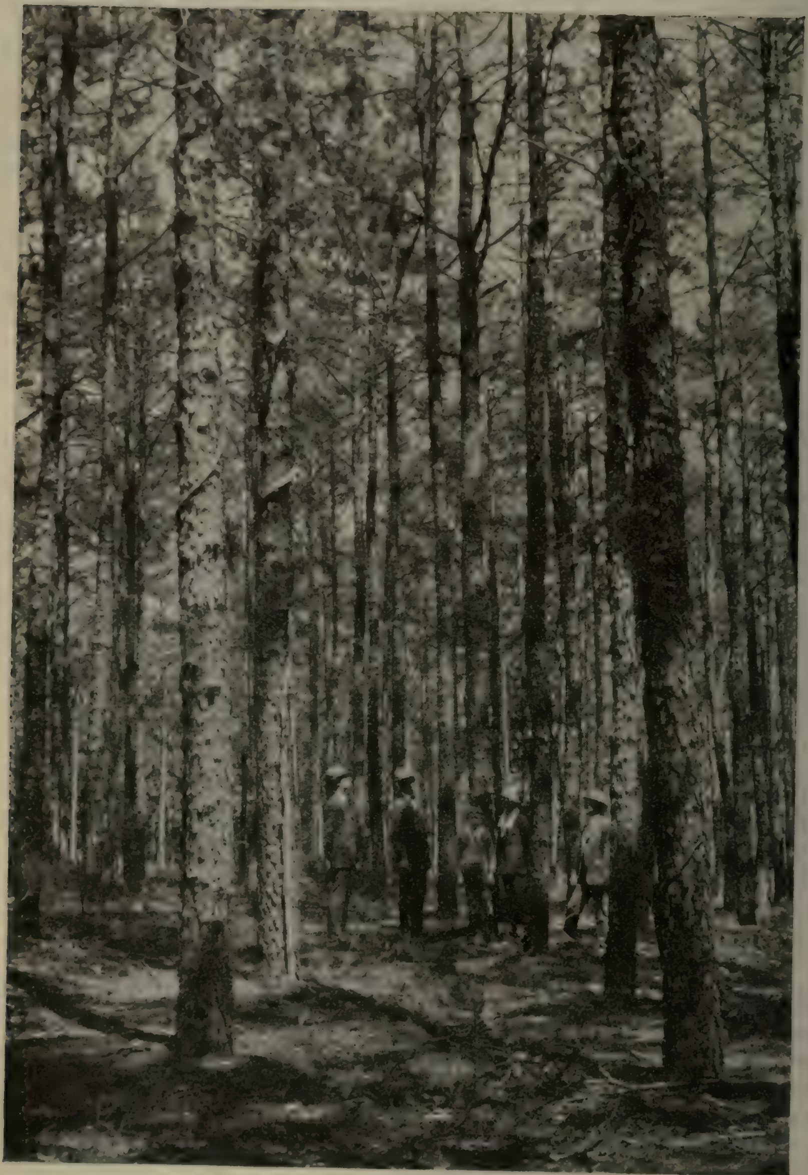

FIGURE 28.—A planted forest, probably the oldest in Dixie's Land. These stately rows of shortleaf pines are the result of planting 10 acres of worn-out cotton fields with pine seedlings in 1892, near Griffin, Ga. The trees were set 8 by 8 feet apart in rows following the terraces. When 35 years old, the trees were 45 to 60 feet in height and from 9 to 14 inches in diameter. The forest is perfect, with dense shade and a thick mat of pine litter protecting the soil and conserving the moisture. The trees have never been injured by a fire

realization of the enormous damage to the timber and forest land and of the money loss to the owner. Although shortleaf pine sprouts successfully when young (pp. 27, 29), fire sets the trees back, causing a loss of time, and has other very injurious effects.

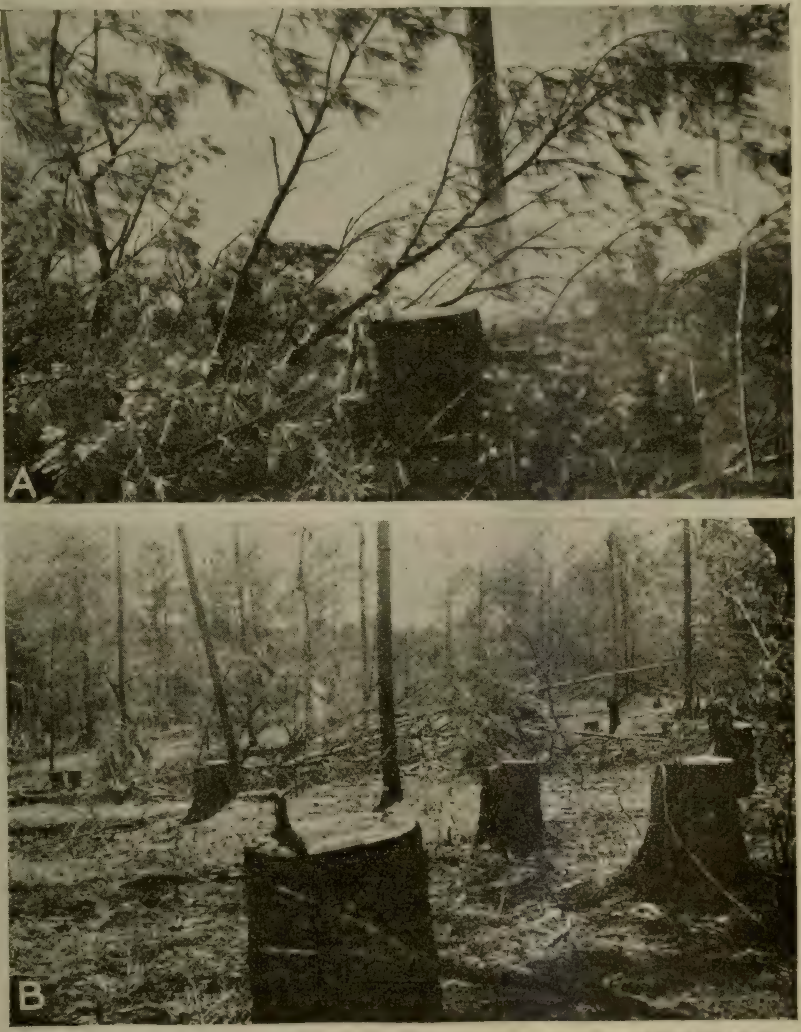

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FIGURE 29.—Fire in shortleaf pine cutting; A, Sweeping through the tops, killing many trees; B, Nearly every tree is blackened and killed by fire. Over 1,000 board feet per acre of good lumber left in high stumps

How does fire affect growing trees?

Fire makes scars ("cat faces") on trees. It so weakens their vitality that insects and fungi find it possible to prey upon the trees, often causing their death.

The stripping of the woods mold off the ground takes away nature's fertilizer; it also removes from the soil nature's mulch, or "clothing" intended to protect the soil and the tree roots against becoming hot and dry in midsummer. When they become hot and dry, as they do wherever the woods humus is lacking, the tree almost ceases to grow during portions of midsummer, for it must have water in abundance.

Fire burns back young growth, or in very dry times so weakens the saplings that they fail to sprout.

> Pine timber grows rapidly when the trees are given enough growing space and are kept from harm by fire.
>
> Timber often pays all the farm taxes—grow it as a crop.

What value has shortleaf "pine" straw as a fertilizer?

According to a recent analysis by the Bureau of Chemistry and Soils, United States Department of Agriculture, a ton of dead leaves or "straw" from shortleaf pine trees contains the fertilizing elements and has the value shown below:

Nitrogen, 14.2 pounds, worth at 15 cents per pound wholesale prices	$2.13
Phosphoric acid, 5.4 pounds, worth at 5 cents per pound wholesale prices	.27
Total value of fertilizer	2.40

The straw has additional value as organic matter. When applied to a piece of crop land, pine straw forms humus or woods mold, which has a high moisture-holding capacity and makes for better aeration of the soil, both important to the health and vigor of growing plants.

What damage is caused by insects?

The southern pine bettle attacks living trees. Outbreaks of this beetle almost invariably occur only during years of extreme drought or locally in places where little rain has fallen for two or three months of the growing season. It is important that close watch of pine stands be kept during unusually dry periods. The adult is a small, dark-brown beetle. In the soft inner bark of the tree it lays eggs which hatch into grubs, often known as "worms." These feed on the rich living layer of inner bark and new wood, thus girdling the tree and causing its death. The life history of this insect is known, and information regarding measures for checking its depredations can be obtained from State entomologists or the Bureau of Entomology, United States Department of Agriculture, Washington, D. C., which has issued a circular for free distribution on the southern pine beetle.

The pine sawyer is a large beetle whose larva, a white grub, bores into the sapwood of dead or felled timber. Its activity may be checked by peeling and drying the timber or immersing it in water.

Young shortleaf pines are sometimes injured by the Nantucket tip moth which attacks the tender young shoots in the early summer. The shoots are often killed, and as a result the tree becomes somewhat deformed and its rate of growth is slowed up. Most trees outgrow the attack successfully. No practical means has yet been found for checking this insect. The references given above should be used in seeking further information upon this important subject.

Are pine trees subject to diseases?

Second-growth, or sap pine under 50 years old, is little affected by "red heart" or other fungous diseases. Wounds caused by fire admit the spores, or "seeds," of fungi, but, as a rule, the vigorous young trees are able to combat them successfully. Probably the antiseptic qualities of the crude turpentine, or gum, help in this matter. After the tree reaches middle age or more advanced ages, red heart is not an uncommon enemy, gradually eating away the heartwood and thus weakening the tree as well as destroying the value of the affected wood. The best protection is to keep out all fires and cut and utilize trees as soon as they show the "bumps," which are good indications of the presence of disease.

There is plenty of land on farms for growing timber as a crop after all the better lands are used for other farm crops and for pastures.

No farmer can afford to pay taxes on idle land. Forest conservation on the farm has come to be a matter of economic necessity.

Forests, unlike many natural resources, can be used and regrown forever. Continuous production of tree crops on lands best suited for the purpose is the aim of forestry.

Since timber and wood are required for the successful operation of the farm, and since most farmers have some lands best adapted to tree growth, the growing of timber as a crop is legitimately a part of the farm program.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1672

DISEASES OF PECANS IN THE SOUTHERN STATES

DISEASES OF PECANS are becoming of more economic importance every year. When the industry was in its infancy, early in the present century, they were of minor economic concern to the grower, and little was known about them.

Rosette was the first serious menace to develop. Then appeared scab, the most destructive disease pecan growers have to cope with, and it is increasing in virulence year by year. A number of other diseases, chiefly caused by fungi that attack the hickories, have made their appearance in pecan orchards.

This bulletin, giving the results of continued investigations into the diseases and their control, supersedes Farmers' Bulletin 1129, Diseases of Southern Pecans.

Washington, D. C. Issued October, 1931

DISEASES OF PECANS IN THE SOUTHERN STATES

By J. B. DEMAREE, *Pathologist, Division of Horticultural Crops and Diseases, Bureau of Plant Industry*

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INTRODUCTION

PECAN GROWING as an industry has developed since 1900 and is of recent origin as compared with the commercial growing of apples and peaches. Until rather recent times little was known about pecan diseases. Prior to 1910 they were of little economic importance. Rosette was the first to develop in a menacing manner and give the growers considerable concern. Later scab made its appearance in commercial plantings, attacking at first only one or two varieties of much importance. Scab is now by far the most destructive disease growers have to contend with and is increasing in importance from year to year.

Other diseases, such as leaf blotch, brown leaf spot, and nursery leaf blight, cause serious damage in some localities in the southern pecan belt, while diseases known as little leaf, edema, and crown gall are of less importance.

It is the purpose of this bulletin to give in a concise, clear, and nontechnical manner such information on pecan diseases as is at present available. Illustrations are presented wherever these will be an aid to readers in recognizing the diseases discussed and to help them distinguish between diseases of major importance and those considered as of only minor importance.

In Farmers' Bulletin 1129, Diseases of Southern Pecans, which is superseded by this bulletin, it was predicted that if due regard were given to the choice of suitable orchard sites, the selection of varieties with special reference to resistance to disease, and proper care of the orchard after it is planted diseases need be of only minor importance and might be expected to decrease. That prediction has been fulfilled only in part. Growers have used greater discrimination in the selection of varieties and orchard sites, and there has been improvement in the care of orchards during the past 10 years. Even so, to-day, with the possible exception of rosette, the earlier-known pecan diseases attack the trees with more virulence than formerly. In the case of scab more varieties are susceptible, and virulent strains of the scab fungus are more widely disseminated. The brown leaf-spot disease has developed from one of minor to one of major importance. Leaf blotch, downy spot, western sooty spot, and Gnomonia leaf spot, now present in many orchards, either were not known 10 years ago or were considered of little importance.

Most fungous diseases that attack pecans also attack hickories, and in most cases the organisms causing pecan diseases were first reported on hickories. It is not known whether these organisms originally were hickory or pecan parasites. Nevertheless, the pecan now seems to be the favorite host of the various fungous parasites capable of attacking the hickory group of trees, of which the pecan is the most important nut producer.

DISEASES DUE TO SPECIFIC ORGANISMS

SCAB

The fungus[1] causing pecan scab is becoming more abundant each year in the humid sections of the southeastern pecan-growing region and is gradually extending into the newer pecan regions where conditions are favorable for its growth. Since the disease is one of the principal limiting factors in pecan-nut production, its control is of prime importance to the new and growing pecan industry in the southeastern part of the United States. The disease may attack the nuts, twigs, and leaves. Some of the best commercial varieties are highly susceptible to it. (Fig. 1.) Although some injury is done to all parts of the trees attacked, the greatest damage is to the nuts. In many localities it annually causes a heavy loss of the crop of the varieties Schley, Delmas, Alley, Pabst, Van Deman, and Success in untreated orchards. There is evidence to show that the fungus causing the disease is gradually adapting itself to Moneymaker, Stuart, and Frotscher, varieties at one time considered highly resistant or possibly immune. Recent experiments indicate that there are different strains or races of the fungus, a fact which explains why scab does not always attack the same varieties alike in all localities.

DESCRIPTION AND LIFE HISTORY

The results of early spring infections frequently are observed first as elongated brown or black lesions along the veins on the under sides of the leaves. Also the early infections frequently cause elongated spots on the ridges of the young nuts. Spots that appear later in the season on leaves, twigs, and nuts as a rule are brown or black, circular (one-eighth to one-quarter of an inch in diameter), and slightly raised above the surrounding tissues. (Fig. 1.) If abundant, the spots on the nuts may coalesce and form large irregular black blotches. In extreme cases, infections on the nuts may be so numerous as to blacken the entire surface. Severely attacked nuts may blacken and drop prematurely, or they may die and remain attached to the twigs for several months.

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[1] *Cladosporium effusum* (Wint.) Demaree.

The disease is carried over from one season to another in the spots on twigs, nuts, or leaf stems. Under favorable weather conditions in April and May, the dormant fungus within the last year's scab spots becomes active and produces spores that infect the new leaves.

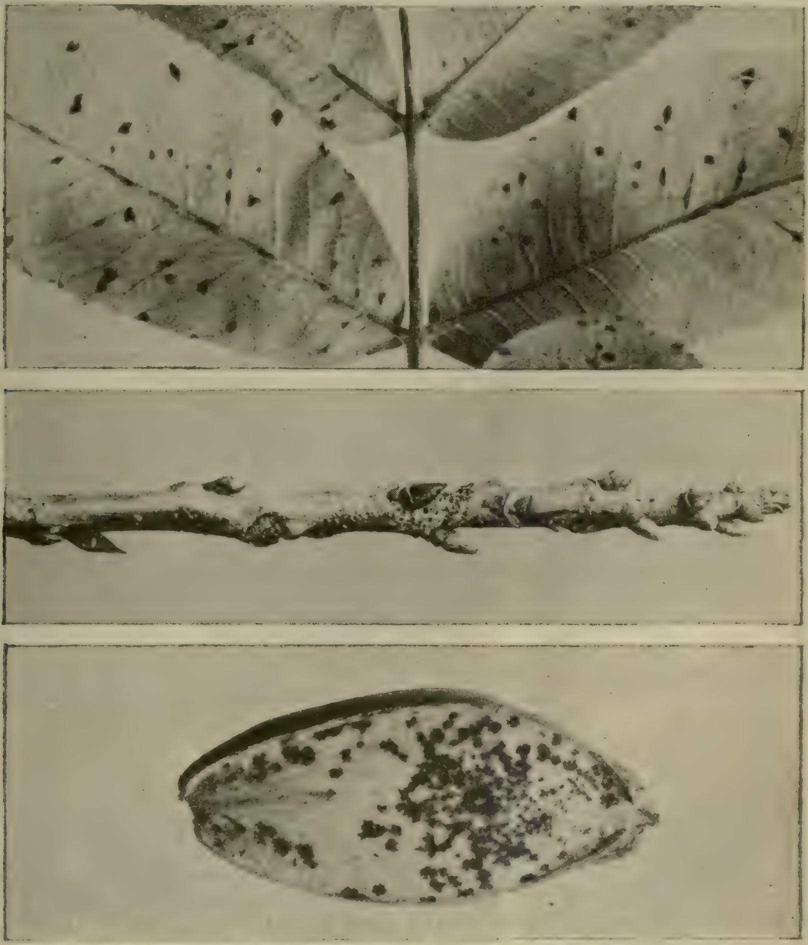

FIGURE 1.—Pecan scab on leaves, a twig, and a nut

Frequent April rains and a low percentage of sunshine favor early spring infections. Under such conditions, initial infection may occur prior to the middle of April in the latitude of southern Georgia; and by the latter part of April or the first week in May, there may be many secondary infections. The young leaves are extremely susceptible while they are unfolding and developing, but become more resistant as they grow older. As soon as the leaves are fully grown and have taken on a dark-green color they are practically immune. The nuts are susceptible until almost fully grown, but only the tender succulent portions of the current season's twig growth are subject to attack. The number of early spring infections can be reduced perceptibly by practicing sanitary measures.

DISTRIBUTION AND ECONOMIC IMPORTANCE

Pecan scab is widely distributed throughout the Southeastern States, having been reported from North Carolina, South Carolina, Georgia, Florida, and Alabama, also from Mississippi, Louisiana, Arkansas, and Texas. The disease causes most damage in the territory embracing northern Florida and the southern portions of Georgia, Alabama, Mississippi, and Louisiana. In this region the disease not only attains its greatest degree of destructiveness but a greater number of varieties are attacked than elsewhere. In the northern half of Georgia, Alabama, Mississippi, Louisiana, and eastern Texas the disease has not yet become serious except on one or two very susceptible varieties, and it is almost absent in the drier regions of Texas. Fewer pecan orchards, lower percentages of humidity, and less frequent summer rains in the more northern and western pecan districts are undoubtedly the main factors contributing to the lesser prevalence of the disease there.

Most varieties are susceptible to infection, but whether or not a variety succumbs to the disease in a section where the fungus thrives depends upon the introduction of a strain or race of the fungus capable of attacking that particular variety. Susceptible varieties may appear immune for a limited period in isolated orchards or even over extensive areas and later succumb to the disease when a suitable strain of the causal organism is introduced and becomes established. The various strains are becoming more uniformly distributed in regions where weather conditions favor the development and propagation of the fungus.

METHODS OF CONTROL

SPRAYING

Extensive experiments over a series of years have demonstrated the efficacy of certain fungicides for controlling pecan scab. Homemade Bordeaux mixture has proved to be the most effective and dependable fungicide so far tried, and has been generally adopted as the standard spray in spite of the fact that under certain unfavorable weather conditions serious foliage injury may result. This type of injury is favored by droughts during August and September. The danger of such injury is greatly lessened if the strength of the Bordeaux mixture is reduced to that of the 3–4–50 formula—3 pounds of copper sulphate, 4 pounds of hydrated lime, and 50 gallons of water. Bordeaux mixture of this composition will hereafter be referred to as 3–4–50 Bordeaux mixture, with the understanding that it is the equivalent of what is commonly called the 3–3–50 mixture, in which the lime is quicklime or stone lime.

The number of applications required for commercial control of scab varies according to the variety, weather conditions, and the distribution of infection sources in the orchard. If the twigs are not badly infected, or if spraying has been carefully done for two or more years, three applications at intervals of about one month should give commercial control. If the trees are badly infected and no previous treatments have been made, heavy early leaf infections are likely to result and four to five applications should be made. Even in spite of thorough spraying in a badly infected orchard the first year's treatment frequently results in unsatisfactory control. Benefits from spraying for the control of pecan scab are cumulative, and the ease and certainty of good control increase with each season's work. A cessation of treatment, as an economy measure during seasons of light crops, loses to the grower all cumulative advantages of previous years' treatments by permitting the reestablishment of the fungus in the orchard. The grower gambles the cost of a year's treatment against the value of a future crop when he permits a respite in the control work for even one year. It is advisable, therefore, to spray annually even though the crop some years may be so light that its value will barely compensate for the money expended on fungicides and labor.

The first application of spray should be made as soon as it is reasonably certain that the pistillate blossoms have been pollinated. Preblossom applications may severely injure the unfolding leaves, which are very susceptible to spray injury. Because it is not good practice to spray while the pistillate blossoms are exposed prior to pollination, the first application should be delayed until after the pollination period. Pollination is considered complete when the tips of the small nutlets have turned brown or black.

Spraying is not a cure for pecan scab; it serves only as a protection against infection. Applications, therefore, should be made frequently enough to keep the nuts covered with a fine film of the fungicide during their entire growing season. Applications at intervals of three to four weeks should accomplish this purpose. (For further information and directions with regard to spraying, see the section on that subject, beginning on page 22.)

DUSTING

Several types of dust fungicides have been tested to determine their efficacy in controlling pecan scab. The following have been used: Flowers of sulphur, colloidal sulphur, oxidized sulphur, dehydrated Bordeaux mixture, and monohydrated copper sulphate and lime dust.

None of the materials tested have given satisfactory results except the monohydrated copper sulphate and lime dust. Under the test conditions, however, this fungicide has not given as good results as Bordeaux mixture. To get the same results as with Bordeaux mixture, more applications at shorter intervals must be made. Four to six applications furnish about the same protection as three to four applications of Bordeaux mixture. The copper-lime dust most commonly used is composed of 20 per cent monohydrated copper sulphate and 80 per cent hydrated lime. This mixture analyzes about 7 per cent copper.

The writer has obtained the best results by making the applications in the early morning while the leaves and nuts are coated with a film of dew or rain. To effect a more even distribution of the fungicide, the dust should be applied from two sides of the trees. When dusting very large trees it is advisable to drive the machine zigzag from one side of the tree row to the other, returning on the same row zigzagging in the opposite direction. This plan will enable the operator to distribute the dust evenly to all sides of the trees.

The amount of dust to be used is determined by the size of the trees. Trees averaging 50 to 60 feet in height and 40 to 50 feet in spread of branches require 10 to 12 pounds per application. Smaller trees require a proportionately smaller amount.

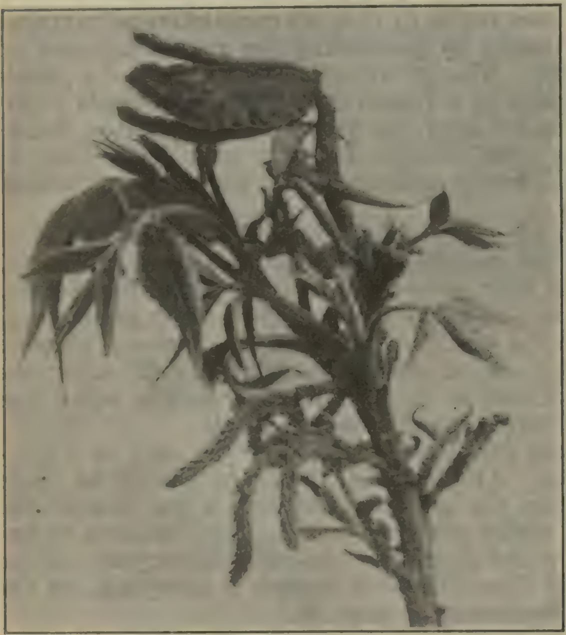

FIGURE 2.—Young diseased leaves. The previous year's infected shucks often remain attached to the twigs over winter and become a source of infection of the young leaves the following spring

ORCHARD SANITATION

Orchard sanitation in pecan-scab control has for its object the disposal of all hold-over sources of infection, as completely as possible, in order to prevent early leaf infection the following season. The fungus lives through the winter on infected twigs, shucks, and leaf stems. Frequently the infected shucks of the previous year cling to the twigs all winter and become important sources of the early spring leaf infections. (Fig. 2.) All such shucks should be removed from the trees before the opening of the growing season, as they are potential sources of infection. An effective method of disposing of them is to plow them under with a turnplow, which places the infected parts so deeply beneath the surface that they are not dragged out by later cultivation. Some growers who own or control extensive acreages of pecans claim that it is not practical to use the turnplow; they use instead disk harrows.

If the sanitation methods are to be complete and effective, the early plowing or disking, if done, should be completed before the opening of the leaf buds; and, to lessen the dispersion of spores from the infective material during the period that the young leaves are so susceptible, further cultivation should lapse until after the first application of spray or dust is made. When the sheet method of harvesting is employed the infected shucks can easily be gathered and removed from the orchard at a small cost. This method of harvesting is not only advisable from the standpoint of disease control, but is also recommended as a means of destroying the larvae of the pecan-shuck worm.

There is no known method of destroying the sources of infection on the twigs. Summer spraying with Bordeaux mixture, however, will largely prevent twig infection. The twigs, therefore, should be relatively free from scab lesions after the first season of spraying.

In southern Georgia, pecan leaves normally begin to unfold during the last week of March, and as the terminals elongate, continue to unfold over a period of about six weeks. The pistillate blossoms become exposed to view some years as early as the middle of April. There is a period of four or five weeks, therefore, during which it is not considered safe to spray, even though the young leaves are then extremely susceptible to infection, because of the danger of injury to the blossoms and the young leaves. The importance of practicing sanitation measures to prevent the leaves from becoming infected during this period can not be overemphasized. Each new infection produces hundreds of spores capable of infecting the later formed leaves and young nuts.

LEAF BLOTCH

The first sign of the leaf-blotch disease[2] is the appearance of brown to greenish-brown spots on the under surfaces of the leaf blades, which later become almost black, due to the presence of minute black pimplelike bodies. The latter stage is the most conspicuous form of the disease and gives it the common name, leaf blotch. The spots, or blotches, vary from one-eighth to one-half inch in diameter, and frequently spots unite to form large irregular blotches which may involve the entire lower leaf surface. (Fig. 3.)

Leaf blotch is a disease of pecan foliage first observed in 1921. Gradually extending its range of distribution, it is now found in practically every pecan nursery and orchard in northern Florida and the southern part of Georgia, Alabama, Mississippi, and Louisiana.

The disease is first found in late June or early July on the older leaflets and may gradually increase until all mature leaves are spotted or killed. On nursery trees the disease first appears on the lower and older leaves, but as the season advances the other leaves are also attacked. Defoliation progresses upward till the first of November, when only a few of the youngest leaves remain. Of the several foliage diseases of budded or grafted nursery trees, blotch is often the most prevalent and is usually responsible for premature dropping of the leaves.

Injuries caused by rosette, general neglect, or any other factor or factors tending to lower the vitality of the trees predispose them to attack by the leaf-blotch fungus. Trees too thickly planted or growing on land receiving no cultivation or fertilizer often lose from one-half to three-fourths of their leaves prior to the harvest season on account of leaf blotch. As a result of such premature defoliation the nuts are of inferior quality, and the crop is light the following season. Trees growing in good soil, well fertilized and properly cultivated, are not attacked so severely as neglected trees.

For suggested methods of control see Brown leaf spot.

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[2] Caused by *Mycosphaerella dendroides* (Cke.) Demaree and Cole.

BROWN LEAF SPOT

Brown leaf spot [3] is one of the most common leaf diseases of the pecan and is distributed throughout the pecan belt. A pecan leaf with the characteristic markings of brown leaf spot is shown in Figure 4. The spots are circular to irregular in outline and vary from one-eighth to one-half inch across. They are usually reddish brown, but the older spots often become grayish and develop concentric zones.

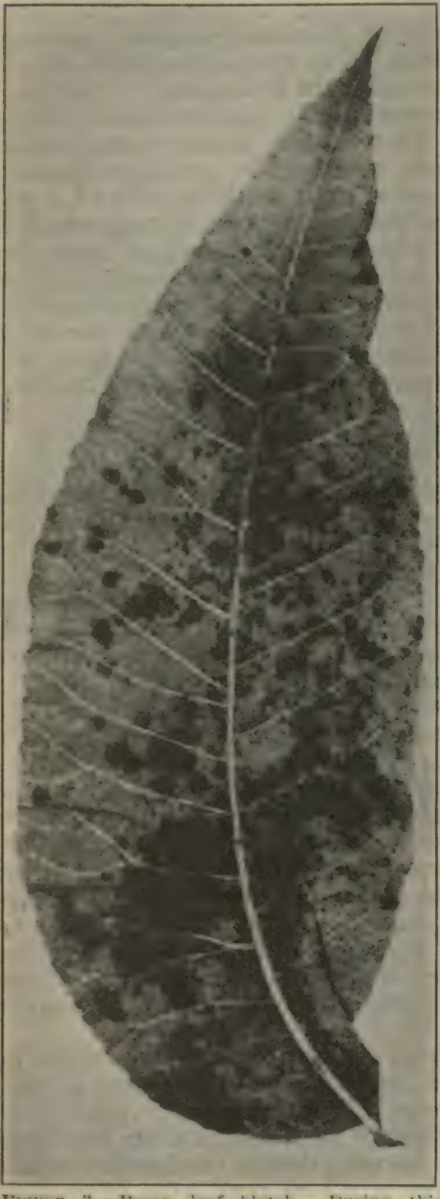

FIGURE 3.—Pecan leaf blotch. During this stage the spots are made up of many small black, pimplelike bodies

This disease rarely appears before the 1st of July, and only fully grown leaves that have developed the dark-green color are susceptible. The disease may increase rapidly after midseason, frequently causing total defoliation.

The Stuart is the most susceptible of the commonly grown varieties. The Moneymaker also may be injured seriously, while the Frotscher and Schley varieties are more resistant.

Until very recently the disease has been considered one of minor importance. Although present in all orchards for many years, the spots have not been sufficiently abundant to cause much damage. Young trees and those of maximum vigor are the most resistant; trees subjected to strong competition on account of close planting, those suffering from a lack of proper cultivation and fertilization, and those affected with rosette are most seriously damaged.

Premature defoliation of the Stuart variety by brown leaf spot is now becoming a common occurrence even in orchards under good management. The leaves become badly infected in August; and defoliation, beginning about the 1st of September, may be completed in three or four weeks.

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[3] Caused by *Cercospora fusca* Rand.

METHODS OF CONTROL

Brown leaf spot and leaf blotch, although caused by different organisms, are both controlled by the same treatments with copper fungicides. Because these diseases were of little economic importance until recently, pathologists did not give them the attention they now deserve, and no definite spray schedule has been formulated. Observations have shown that in numerous cases three and four applications of Bordeaux mixture intended to control pecan scab entirely prevented infections by leaf-blotch and brown leaf-spot fungi. Figure 5 shows the results in controlling leaf blotch by dusting with a mixture of 20 per cent monohydrated copper sulphate and 80 per cent hydrated lime, and Figure 6 shows what may be done in controlling brown leaf spot with one application of Bordeaux mixture in late July.

For the protection of pecan foliage against damage from these two diseases, it is tentatively recommended that two applications of Bordeaux mixture or three applications of copper lime dust be made during June and July, beginning about June 15. If the liquid is used, the second application may be made about the middle of July, but the intervals between the applications of dust should be not more than three weeks.

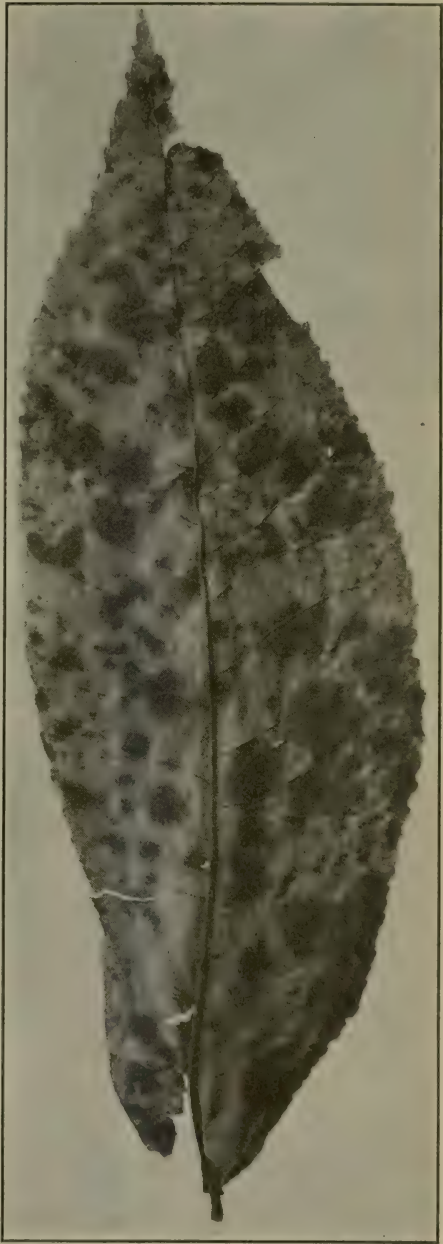

FIGURE 4.—Brown leaf spot of pecans

NURSERY BLIGHT

Pecan nursery blight is a leaf disease [4] of young nursery trees and occurs rarely in orchards.

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[4] Caused by *Phyllosticta caryae* Peck.

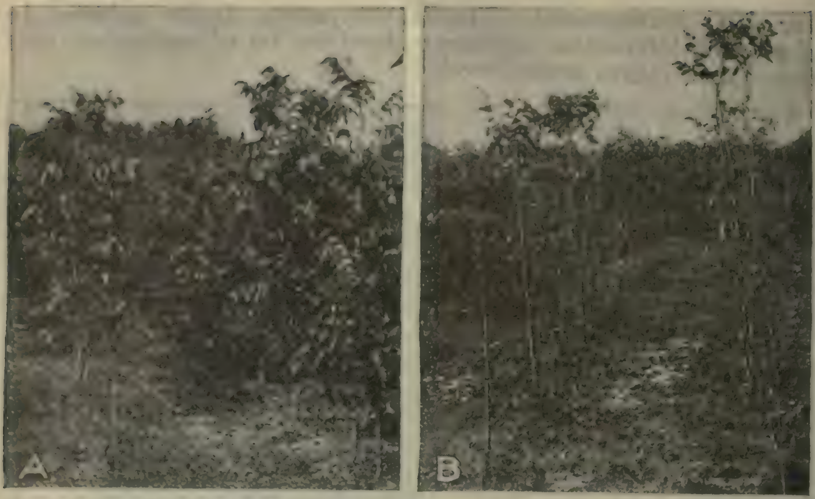

FIGURE 5.—Pecan leaf-blotch control; A, Trees dusted five times with a mixture of 20 per cent monohydrated copper sulphate and 80 per cent hydrated lime; B, untreated plot. (Both plots photographed November 16, 1928)

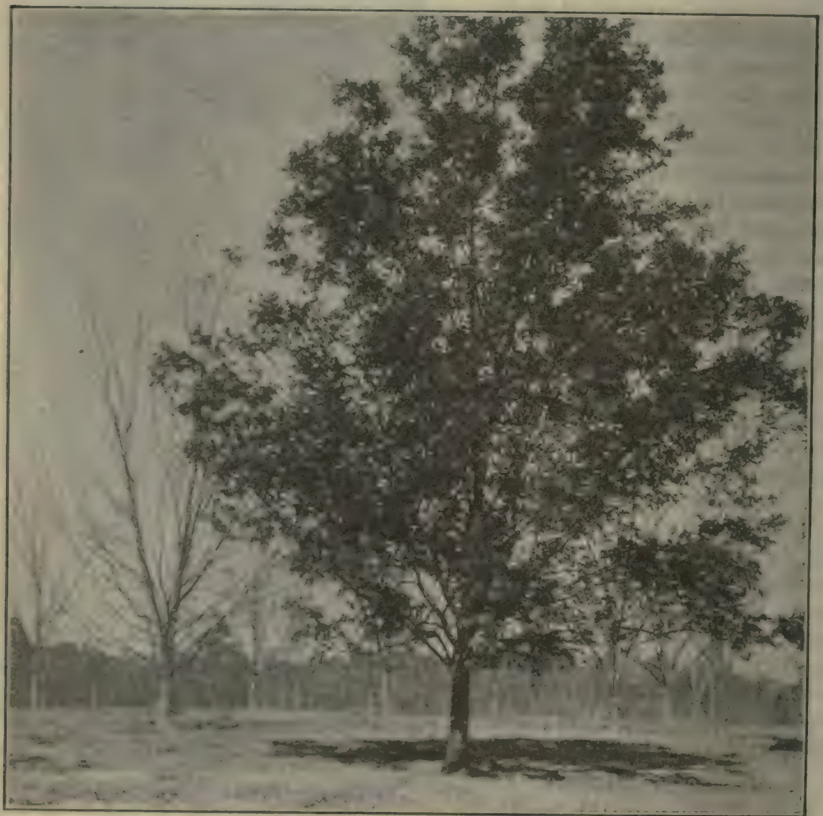

FIGURE 6.—Pecan leaf-spot control. Trees in the background not sprayed. The one tree in the foreground was sprayed once in late July with a 3–4–50 Bordeaux mixture. (Stuart variety; photographed November 23, 1929)

It is widely distributed throughout the southern pecan belt, and is of considerable economic importance in pecan nurseries because in wet seasons it causes heavy defoliation. Pecan seedlings badly affected with nursery blight make little growth and sometimes are too small for budding at the end of the second year's growth, when most of the budding is done.

The disease first appears in April as small reddish spots on both sides of the leaves; later the color of the spots on the upper surface turns gray. Spots are most abundant along the veins or the margins of the leaves. The dead leaf tissues become brittle and break out, leaving irregular ragged margins and perforations. (Fig. 7.) Single spots are seldom more than one-eighth of an inch in diameter, but two or more spots may unite. While late-season infections may occur at any point on the upper leaf surface, they most commonly occur along the midribs and larger veins, as illustrated in Figure 8.

Nurserymen who spray to control this disease make four or five applications of Bordeaux mixture at intervals of three or four weeks. The first application should be made soon after the first leaves have formed and before infections have begun.

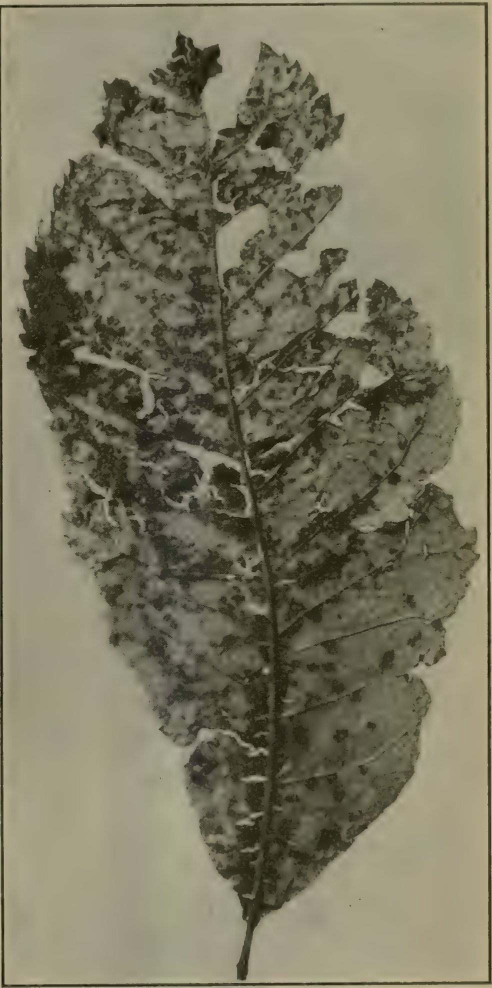

FIGURE 7.—Nursery blight on young pecan leaflet

CROWN GALL

Crown gall,[5] as the name implies, manifests itself as enlargements on the roots or collars of the trees. Figure 9 shows a typical case of crown gall on a nursery tree. On account of its rare occurrence it has been considered a distinctly minor disease of pecan trees in orchards. It is more often seen on young trees as they are dug from the nursery row. Nursery trees should be inspected before planting, and those showing such enlargements should be discarded.

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[5] Caused by *Bacterium tumefaciens* Smith and Town.

POWDERY MILDEW

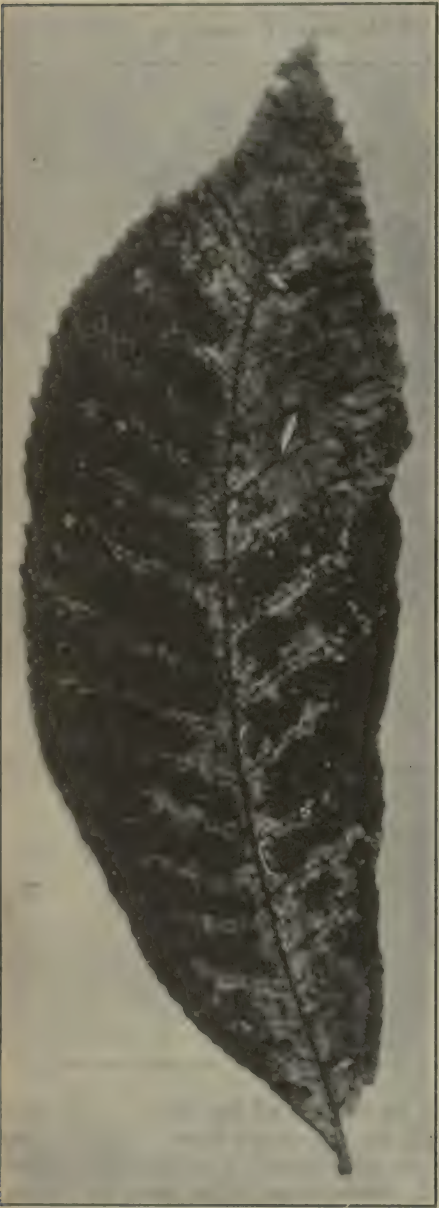

FIGURE 8.—Pecan nursery blight as it often appears on mature leaflets

The powdery-mildew fungus[6] forms a white superficial growth on both leaves and nuts of the pecan. It appears during May, June, and July, especially in seasons of considerable rainfall and high humidity. Owing to its habit of coating the leaves and nuts with the white powdery growth, it frequently causes growers some concern. Usually, infected nuts develop normally and show no evidence of injury, but occasionally considerable damage is done to the most susceptible budded trees and planted seedlings in the piedmont region of Georgia. Severe cases that result in a reduced size of nuts and shriveled kernels are comparatively rare. The Pabst is the most susceptible of any of the more commonly grown varieties.

WESTERN SOOTY SPOT

The western sooty spot[7] is a pecan-leaf disease, confined, so far as known, to Texas and Louisiana. It has been found in Oklahoma and Georgia on hickory leaves and probably is present in Oklahoma and Arkansas on the pecan.

Circular spots one-fourth to one-half of an inch in diameter develop on the under sides of the leaflets during midsummer and are not very different in color from the adjacent leaf tissues, being greenish brown and, therefore, inconspicuous. (Fig. 10.) They can best be seen at this stage when held against a strong light. During October, when the diseased tissues die and change to a lighter color, minute, black, pimplelike structures containing spores appear in the spots. At this time the spots are evident also on the upper side of the leaflet.

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[6] *Microsphaera alni* (Wallr.) Wint.

[7] Caused by *Gloeosporium caryae* var. *curvisporum* Dearn.

GNOMONIA LEAF SPOT

The Gnomonia leaf spot[8] is another pecan disease of minor importance, occasionally observed in Florida and the southern part of Georgia. It first appears in June as a small, inconspicuous brown spot with no certain diagnostic features. The spot may enlarge to one-half of an inch or more in diameter and become almost black in color. The shape of the spots varies from circular to greatly elongated. The most distinguishing characteristic of the Gnomonia leaf spot is that affected areas are frequently confined to a narrow space between two lateral veinlets, forming a long narrow dead area. (Fig. 11.) The disease has not become serious enough to justify the use of remedial measures.

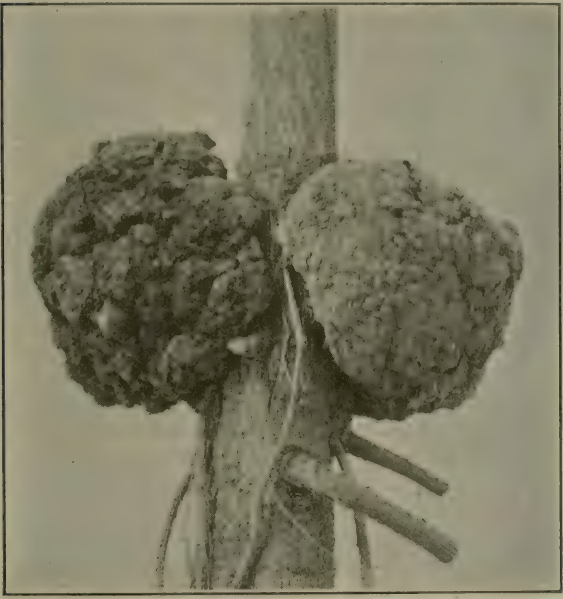

FIGURE 9.—Crown gall on pecan nursery trees

DOWNY SPOT

Downy spot[9] is a name given to a leaf disease first found on hickory trees in Ontario, Canada, in 1889, but not observed on the pecan until 1926. White or downy spots appear on the under sides of the leaves during the latter part of May or early in June. (Fig. 12.) These are made up of innumerable spores or conidia of the fungus, which are easily washed off by rains, leaving faint yellowish spots. Later these spots may change to brown and extend through to the upper sides of the leaves. In 1927 this disease in southern Georgia was serious enough to cause some defoliation. The following year it was much less in evidence. How important it may become is not known at present. The Delmas and Moneymakers seem to be more susceptible than the other commercial varieties.

The writer has conducted no experiments for controlling this new disease of pecans, but the fact that five and six applications of the monohydrated copper sulphate and lime dust used to prevent scab had no effect indicates that it may be hard to control.

WOOD ROTS

Wounds made in pruning pecan trees and those arising from other mechanical injuries, such as careless cultivation, winter injury, and windstorms, are all possible points of entrance for wood-rotting fungi. The hot, humid climate of the Southeastern States favors the rapid development of these fungi; and unless wounds are given protection from infection and so handled as to facilitate healing, it is inevitable that fungi will gain entrance and endanger the life of the entire tree.

---

[8] Caused by *Gnomonia* sp.
[9] Caused by *Cercosporella caryigena* (E. and E.) Von Hohnel.

Growers wishing to change the varieties in their orchards to more desirable ones cut back the tops of the trees and bud or graft to the selected variety. In many instances this necessitates severing large limbs and making wounds that require two or more years to heal. When removing a limb, the orchardist should make a preliminary cut on the under side about one-quarter through the limb, as a safeguard against splitting the limb or tearing off the bark. When removing a limb entirely, he should make the second cut almost flush with the body of the tree, as such a wound heals more readily. (Fig. 13.) Entrance of wood-rotting fungi into wounds can usually be prevented by painting the cut surface carefully and thoroughly with some antiseptic tree-wound dressing. Ready-prepared wound dressings may be purchased or a good paint prepared at home by combining coal tar with creosote. A sufficient quantity of creosote should be mixed with the coal tar to form a paint of such consistency that it can be spread readily with a brush. Ordinarily the proportion will be about 1 part of creosote and 4 parts of coal tar. The wound should be painted immediately after it is made, and once or twice annually thereafter until completely healed.

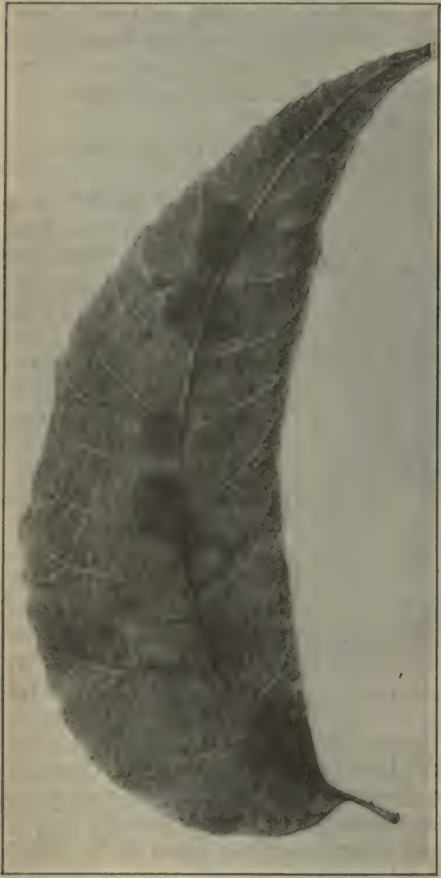
FIGURE 10.—Pecan western sooty spot as it appears during midsummer

DISEASES DUE TO ENVIRONMENTAL FACTORS

ROSETTE

In its earliest stages, or on slightly affected trees, rosette is indicated by a slight yellowish mottling of the leaves. In more distinct cases the leaflets are slightly narrowed and crinkled. When trees are severely affected the leaflets are extremely narrowed, with either reddish-brown areas or perforations between the leaf veins. (Fig. 14.) Checking of the new twig growth causes the shortened internodes and the bunching of the foliage that have suggested the name rosette. In the final stages of the disease the twigs die back from the tips. Usually the dying back is confined to the current year's growth, but sometimes in severe cases of rosette it extends to branches of considerable size. Seriously affected trees rarely bear nuts, and those borne may be small. The writer has never seen a tree that has died as the direct result of rosette, but affected trees frequently become so weakened and misshapen as to be worthless. (Fig. 15.)

The cause of pecan rosette is not definitely known, but it is in some way related to unfavorable soil conditions.

With few exceptions there is not much variation in the susceptibility of varieties to rosette. The Stuart is probably the most susceptible, with Van Deman and Frotscher following closely. Of the varieties exhibiting resistance, the Moneymaker is the only one of outstanding merit in this respect. This variety is strikingly resistant and though not of high quality is probably the best to use to topwork rosetted trees where other methods recommended for curing the disease have failed. If orchards are to be planted in deep sandy soils, impoverished soils, or other soils that may induce rosette, the Moneymaker variety is the best to plant, but planting to any variety in such soils is not likely to be profitable.

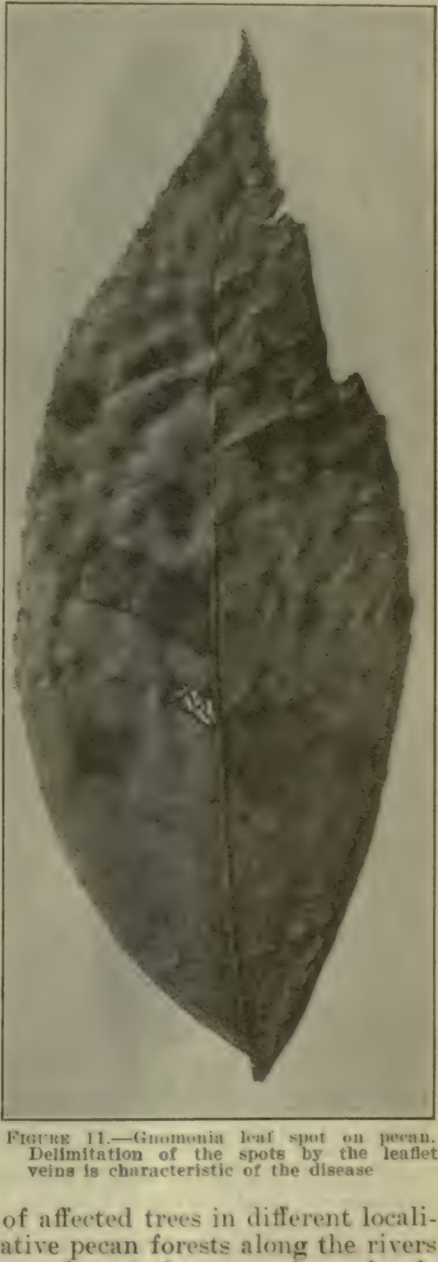

FIGURE 11.—Gnomonia leaf spot on pecan. Delimitation of the spots by the leaflet veins is characteristic of the disease

The disease is found in all Southern States from Texas to North Carolina, but there is a marked difference in the number of affected trees in different localities. Although rarely found in native pecan forests along the rivers of Texas and Louisiana, the disease frequently occurs in orchards planted on the upland soils of these States. By far the greatest number of rosetted trees is found in orchards planted on the typical sand, sand-clay, and clay soils of the Atlantic and Gulf coastal plains. The disease is most prevalent on deep sandy soils, eroded hillsides, impoverished cotton lands, and soils with a stiff, semi-impervious subsoil. In the coastal-plain regions trees growing in any soil deficient in humus may become rosetted. The disease seldom affects an orchard uniformly, but attacks those trees growing on the lighter and sandier soils. Trees growing in low places where humus and fertilizing materials accumulate are usually thrifty and free of rosette. There are, however, some apparent contradictions to these observations.

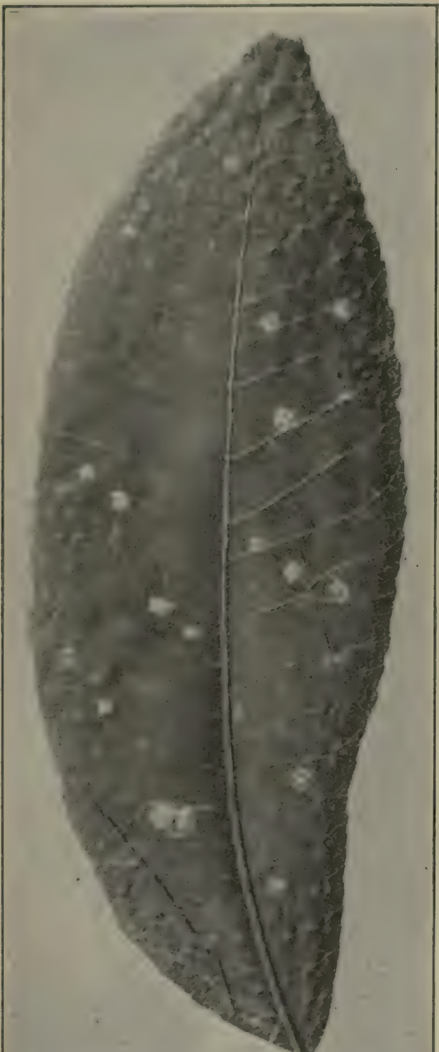

FIGURE 12.—Downy spot of the pecan. During an early stage of the disease the markings are white, caused by the presence of innumerable white spores. Rains wash away the spores, leaving faint yellowish areas

Sometimes rosette is present in trees growing in what appears to be a very fertile soil, but borings usually will reveal that this soil is underlain with a thick stratum of sand or hard, impervious clay. In the delta of Louisiana, rosette sometimes affects trees growing on fertile garden soils or near barns, pigpens, or feed lots, where its presence may be due to a lack of balance in the supply of plant-food materials or to a deficiency in some of the essential elements, such as calcium.

TREATMENT

On soils readily susceptible to improvement, rosette may be overcome by consistently following some soil-building program. This program should include as its principal feature the application of organic matter in some form to the soil each year. Applications of stable manure have consistently given the quickest and most striking results. Leaf mold, swamp muck, undecomposed forest leaves, and cane pomace, either used as a mulch or plowed into the soil, have given good results. In the larger orchards the growing and plowing under of leguminous cover crops have proven to be the most practical and successful remedy. Ordinary commercial fertilizer alone apparently is not a direct remedy, but its use with the cover crop is highly advantageous, not only in furnishing plant food to the trees but in inducing a more luxuriant growth of the cover crop to be turned under. The writer has considerable evidence that frequent summer cultivation, especially if deep, favors the occurrence of rosette. Therefore, until there are adequate experimental data to disprove this theory, it may be advisable to reduce the depth and number of cultivations in rosetted orchards to a minimum consistent with good horticultural practice.

Restoration of rosette-affected trees is usually slow, and attempts to cure the disease are frequently discouraging. A badly rosetted tree is slow to respond and requires at least two years of treatment before results are evident. The time required to effect recovery depends upon how intensively the corrective measures are used and also upon the nature of the soil. In some instances where the subsoil is composed of a stratum of sand more than 2 feet thick it may be best to abandon the trees.

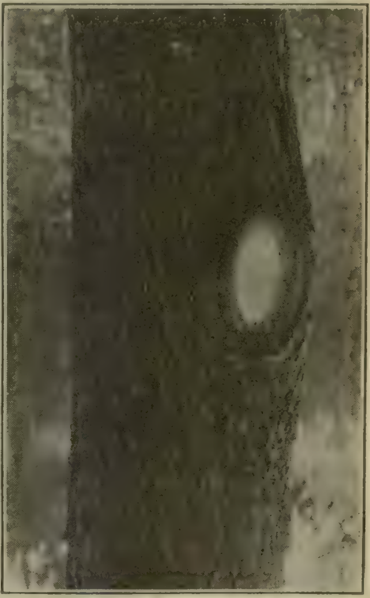

FIGURE 13.—Wound left by removal of a large limb. Such wounds heal more readily if the cut is made almost flush with the trunk

SAND BURN

Sand burn is a name applied to a dying of young pecan seedlings during their first year of growth and is caused by excessively high temperatures of the surface soil. The young seedlings are girdled near the ground, or the terminal bud is killed as it attempts to push through the hot surface layer of soil. The portion of the seedling above the girdled area dies gradually, the leaves blacken and usually remain attached. The uninjured part of the seedling below the girdled section may send up one to several shoots, simultaneously or successively, which in turn may be killed as the terminal bud reaches the surface of the hot soil. (Fig. 16.)

Sand burn is frequently the most important factor contributing to poor stands of seedlings in pecan nurseries. It causes greater mortality when the seeds have been planted late, when seeds of poor quality have been used, and when high temperatures occur during May and June following the planting. Therefore, the planting of high-grade nuts during the early part of the winter, the avoidance of deep sandy soils devoid of humus and subject to overheating, and the selection of a nursery site having no westerly exposure are recommended as measures tending to lessen the danger of heavy loss by sand burn.

Work done at the United States Pecan Field Station near Albany, Ga., indicates that the trouble can be practically eliminated if the seedlings are grown the first season in close beds under partial shade and transplanted to the open field the following year.

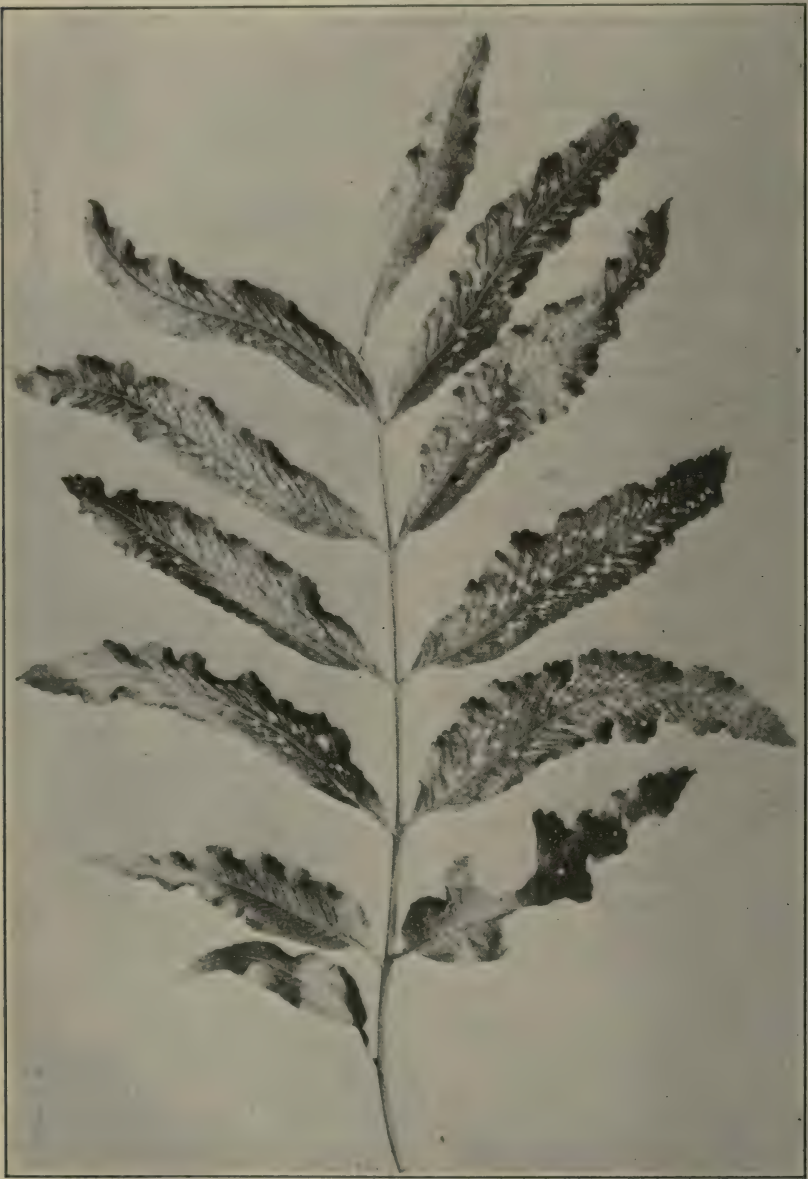

FIGURE 14.—Pecan rosette. A pecan leaf affected with rosette, showing narrow, crinkled leaflets with perforations

LITTLE LEAF

In the more pronounced cases of pecan little leaf, the leaflets are both shortened and narrowed, the width being reduced to about one-third of an inch. The leaf itself is often reduced to a length of only 1 to 2 inches, exclusive of the petiole, or leaf stem. A slightly affected leaflet may be normal in size, the only visible symptom of the disease being the obtuse apex. (Fig. 17.) Some trees observed have been so severely affected that all their leaves were composed of leaflets of the extremely rounded and diminutive type. In other trees the disease may be found only on certain branches, recurring there each year while other limbs of the same trees produce normal

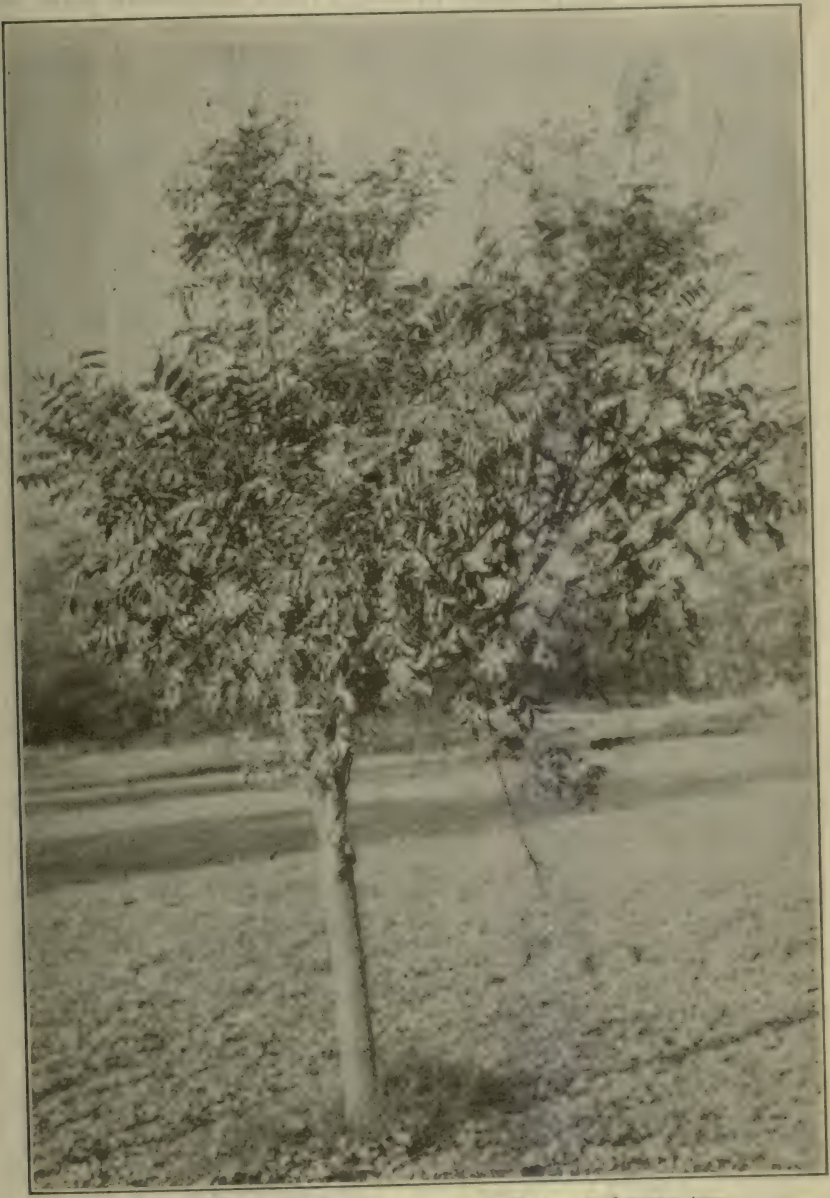

FIGURE 15.—A typical specimen of a badly rosetted pecan tree

leaves and twigs. Badly affected trees do not bear nuts, and their growth is greatly retarded. The writer has evidence that some trees recover after one or more years, while it is definitely known that the trouble has persisted in others for a number of years.

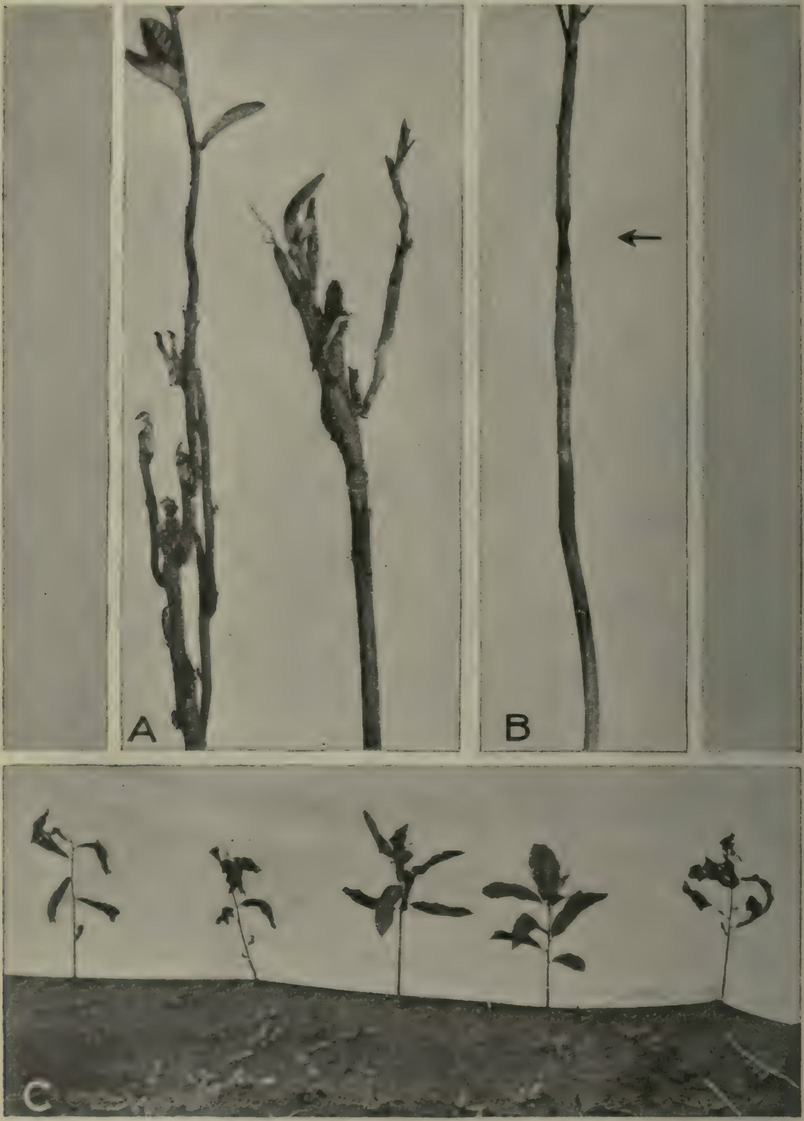

FIGURE 16.—Sand burn of pecan seedlings: A, How the sprouts are killed as they emerge from the soil surface; B, a seedling girdled just above the ground line; C, the second seedling from the right is normal; the others are either dead or dying

The disease is of minor importance, as it seldom affects trees growing under orchard conditions. When found it is usually in trees growing in city gardens and lawns. It has been seen in a number of towns in States bordering the Atlantic and Gulf coasts from North Carolina to Mississippi. Experiments indicate that little leaf is not transmissible from diseased to healthy trees and is not becoming noticeably more abundant. The cause of the disease is not known.

WINTER INJURY

Winter injury causes an annual loss of many young pecan trees and is considered a rather serious problem by owners of young orchards. The symptoms are quite striking. Injured trees put out leaves in the spring as if normal and grow for several weeks on the food stored in the trunk and limbs, then suddenly wither and collapse. An examination made at this time reveals that parts of the trunk had been previously injured, as evidenced by the discolored inner bark and by the sour odor. The original injury may have been confined to a narrow band near the surface of the ground, but by girdling the trunk it sufficed to cause the tree to die above ground. The roots of affected trees as a rule do not die, but send out sprouts from below the dead parts. (Fig. 18.) Soon after the bark tissues

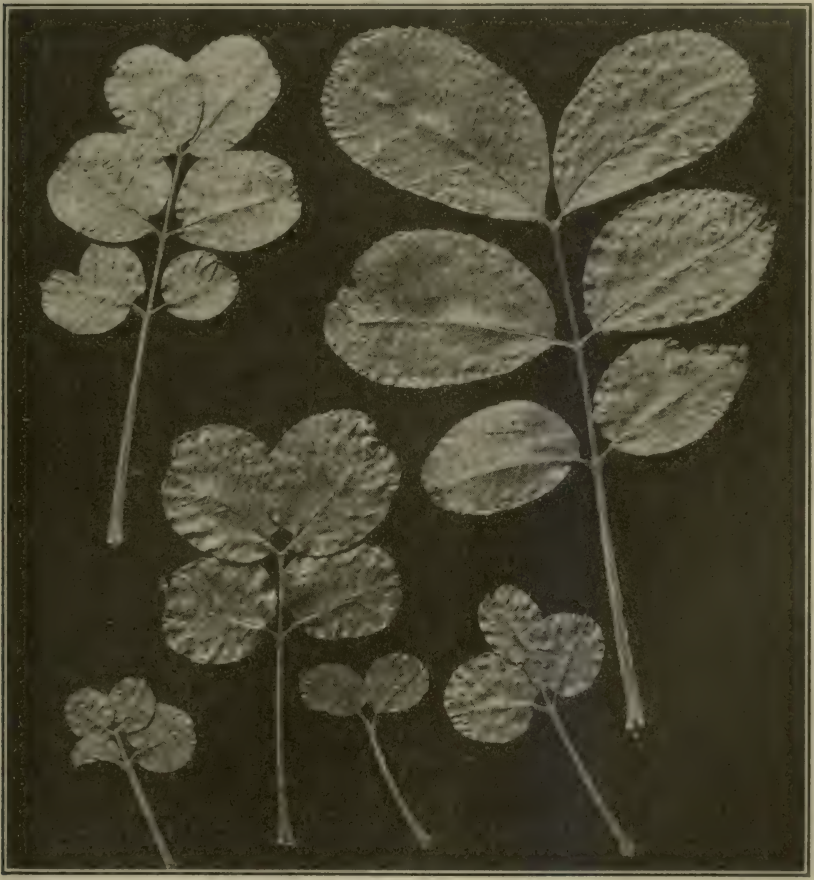

FIGURE 17.—Little leaf disease of pecan

are damaged almost invariably shot-hole borers riddle the bark with many small holes; growers consequently often attribute the dying of the trees to borer infestation.

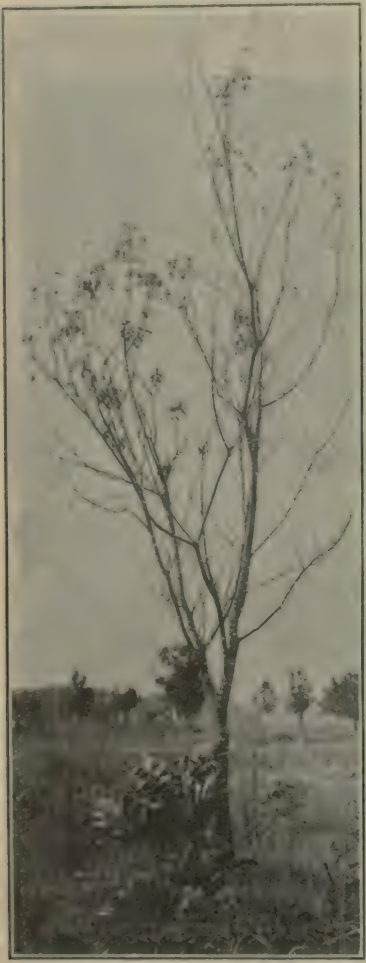

FIGURE 18.—Winter injury of a young pecan tree. The leaves developed normally during early spring and then died in May. Later in the season sprouts formed from the uninjured roots

Winter injury is caused by sudden and excessive changes in temperature during the late fall and winter. Young trees 3 to 5 years old that have made a late growth are the most susceptible. Trees over 9 or 10 years of age are seldom infected.

To guard against dangers of winter injury, young orchards should not be given deep cultivation or nitrogenous fertilizers during the latter half of the growing season. If the growth of the trees is stimulated during the fall, their susceptibility to winter injury is increased. Loss of young trees by winter injury can be entirely prevented by wrapping the trunk of each tree during the fall with a gunny sack, as shown in Figure 19.

A few growers make a practice of splitting the bark of frozen trees. There is no merit in this supposed remedy; indeed, it may cause much harm by exposing the underlying bark and cambium tissues to fungus infection.

EDEMA

Infrequently spots of striking character form on the trunks of young pecan trees, as illustrated in Figure 20. They are light or cinnamon brown, slightly raised, and often cracked. The interior of the affected areas is composed of dead tissues that are dry and spongy and finally become more or less powdery. They do not extend deep into the bark and apparently cause little or no damage. This trouble belongs to the general type of physiological disease commonly called edema. Diseases of a similar nature have been reported as occurring on other plants. The exact cause of edema is not known.

SPRAYING

Spraying is the principal control measure for some of the diseases under consideration and also for certain insects. A general spray schedule for combating diseases and insects in southern pecan orchards has been prepared in collaboration with the Bureau of Entomology and appears as Table 1.

TABLE 1.—*Spray schedule for combating pecan diseases and insects*[1]

Application and time	Material	Diseases and insects to be controlled	Remarks
No. 1.—Immediately after pollination has taken place; when the tips of the small nuts have turned brown.	3-4-50 Bordeaux mixture plus 40 per cent nicotine sulphate at the rate of ¾ pint to each 100 gallons of Bordeaux. To control aphids on nonscabbing varieties use 40 per cent nicotine sulphate at the rate of ¾ pint to 100 gallons of water plus 4 pounds caustic-potash fish-oil soap.	Scab; aphids.	Both surfaces of leaves should be covered for protection against scab and to kill all aphids. For aphid control centers of trees should be sprayed as thoroughly as outer parts.
No. 2.—Three weeks after No. 1.	3-4-50 Bordeaux mixture.	Scab.	A good coverage of the nuts is very important for this and all later applications. If webworms and caterpillars are abundant, add 1 pound calcium arsenate to each 50 gallons of Bordeaux mixture.
No. 3.—Three weeks after No. 2.	3-4-50 Bordeaux mixture.	Scab; leaf blotch; brown leaf spot.	Spray as directed in No. 1. If aphids are present in abundance at this time add 40 per cent nicotine sulphate as in spray No. 1.
No. 4.—Three weeks after No. 3.	3-4-50 Bordeaux mixture; calcium arsenate 1 pound to each 50 gallons Bordeaux plus 40 per cent nicotine sulphate at the rate of ¾ pint to each 100 gallons of the spray (add nicotine last).	Scab; leaf blotch; brown leaf spot; leaf case-bearer; aphids.	Spray as directed in No. 1.

[1] This spray schedule was designed by J. B. Demaree, pathologist, Bureau of Plant Industry, and G. F. Moznette, entomologist, Bureau of Entomology, to meet conditions in southern pecan orchards.

PREPARATION OF BORDEAUX MIXTURE

As stated previously, Bordeaux mixture can be used safely, economically, and effectively in pecan orchards for the control of various diseases. Furthermore, there is no better or cheaper form of Bordeaux mixture known than that made at home with bluestone (copper sulphate), lime, and water.

For the sake of simplicity of equipment, economy of labor, and uniformity of the product, growers are advised to use the powdered or "snow" form of bluestone and a high-grade hydrated lime for making Bordeaux mixture. Powdered bluestone or copper sulphate is in particles about the size of granulated sugar and dissolves rapidly in water. It can be dissolved while the spray tank is being filled. Probably the most practical way to dissolve this powder is to place the required amount in a closely woven sack suspended within the tank and allow the inflowing water to wash through it by inserting the end of the intake hose in the open end of the sack. The "snow" form of bluestone costs slightly more than the large crystals, but the added cost is offset by the saving of time and labor in dissolving it. Hydrated lime can be purchased almost anywhere in 50-pound paper sacks. Although hydrated lime as ordinarily sold in the Southeastern States, especially that manufactured in Alabama and Tennessee, is usually satisfactory for making Bordeaux mixture, growers nevertheless should demand that it contain at least 68 to 70 per cent calcium oxide. The use of hydrated lime has several advantages. It is properly slaked when purchased, and if stored in a dry place will not deteriorate rapidly; it is relatively free from grit, and a suspension, or "milk," may be prepared in less time than is required with quicklime. The only equipment necessary is a tub or keg in which the lime can be mixed with enough water to make a milk of lime that pours readily. Investigations have shown, however, that dry hydrated lime disperses slowly in water, and therefore makes a better grade of Bordeaux mixture if allowed to soak for an hour or more before the spray is made.

A 3-4-50 Bordeaux mixture for use in a 300-gallon power-spray outfit may be prepared in the following manner:

Weigh out 18 pounds of powdered bluestone (copper sulphate) and 24 pounds of hydrated lime.

Start filling the tank with water. The bluestone should be dissolved within the tank while it is being filled as described above. When the tank is about three-fourths full, the engine should be started, to operate the agitator; and when all the bluestone is dissolved, the milk of lime should be added slowly. If a spreader or an insecticide is to be used it should be put in after the milk of lime.

Complete filling the tank with water and spray is ready to be applied.

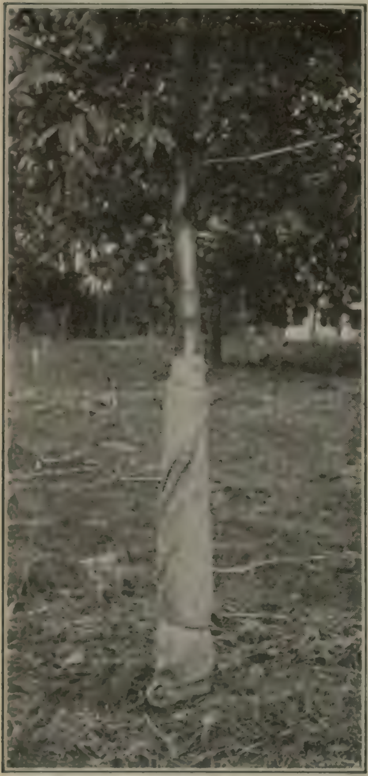

FIGURE 19.—Method of wrapping young pecan trees with gunny sack or burlap to prevent winter injury

THE SPRAY OUTFIT

In the past there has been a tendency among pecan growers to provide themselves with small-sized spray outfits that were usually equipped with small motors capable of developing only 3 to 5 horsepower. Without exception, machines of that type have proved decidedly unsatisfactory in bearing pecan orchards and have been the source of many discouraging attempts to combat pecan pests.

Very heavy portable outfits such as are used in the fight against forest-tree insects in the New England States or machines designed for park and roadway tree spraying are at present also unsuitable for pecan-orchard spraying, chiefly because their weight is a drawback when they are used in wet or cultivated fields.

Stationary spray outfits have not as yet been given a fair trial in pecan orchards, and they can not at present be recommended. Unless a tower can be employed it is doubtful whether stationary outfits, with the spray guns now available, will prove satisfactory in pecan orchards where the trees are over 40 feet in height.

What may be termed the medium-sized high-pressure portable spray outfits have given the best service. Such machines are equipped with motors capable of developing from 15 to 20 horsepower and have pump capacity ranging from 25 to 35 gallons per minute. A tank holding 300 gallons of spray mixture is most generally used. When selecting a machine for pecan-tree spraying the following points should be considered: The pump should possess a capacity greater than is required to operate at least two spray guns; one gun should be of the long-distance mist type capable of discharging from 15 to 20 gallons of liquid per minute; the other gun may be of a smaller type which will discharge 5 to 8 gallons per minute; and the motor must possess sufficient power to operate the pump with both guns open and yet maintain a pressure of 300 to 400 pounds as indicated on the pressure gauge when connected to the pump.

Each spray outfit should be provided with two leads of hose. The one that conveys the liquid to the long-range gun operated from the tower should be three-fourths inch in diameter and need not be over 15 or 20 feet in length. The hose that carries the spray to the small spray gun used on the ground can be one-half inch in diameter, but should be 50 to 75 feet long. The length will depend upon the distance between the trees, as the work with the small gun should precede by one tree that of the long-distance gun so that the drip from the tops of the trees will not interfere with the efficiency of the close spraying. All hose should be equipped with clamp couplings that will not blow off when operating under a pressure of 300 to 400 pounds.

A tower is considered a necessary adjunct to any spray outfit used in pecan orchards over 15 years old. (Fig. 21.) The ordinary short spray gun can not be expected to furnish good distribution beyond 20 to 25 feet from the ground. Some pecan trees are now 60 feet and over in height, and even when the long-distance spray gun is used, their tops can not be well sprayed without a tower.

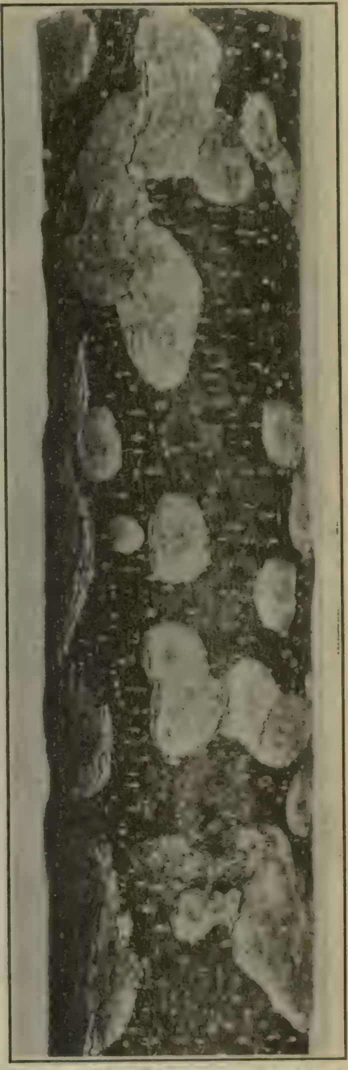

FIGURE 20.—Edema on the trunk of a young pecan tree

APPLYING THE SPRAY

The first scab application is made at a time when a large majority of the leaves are susceptible to scab infection. It is important, therefore, to give the leaves adequate protection. Since the lower surface of pecan leaves is most susceptible to infection by the scab organism, one gun operator should work under the trees directing the spray upward and distributing it to the undersurface of the leaves of the lower limbs and to those leaves, twigs, and nuts growing inside the periphery of the tree not easily covered from the tower.

The early-formed leaves are practically immune to scab infection by the time the second application is made. Therefore, leaf coverage is not so important after the first application has been made except that all new leaves formed during the intervals between applications should be protected with the fungicide. As far as combating scab is concerned, the purpose of the last three applications is primarily to protect the nuts. A very large percentage of the early

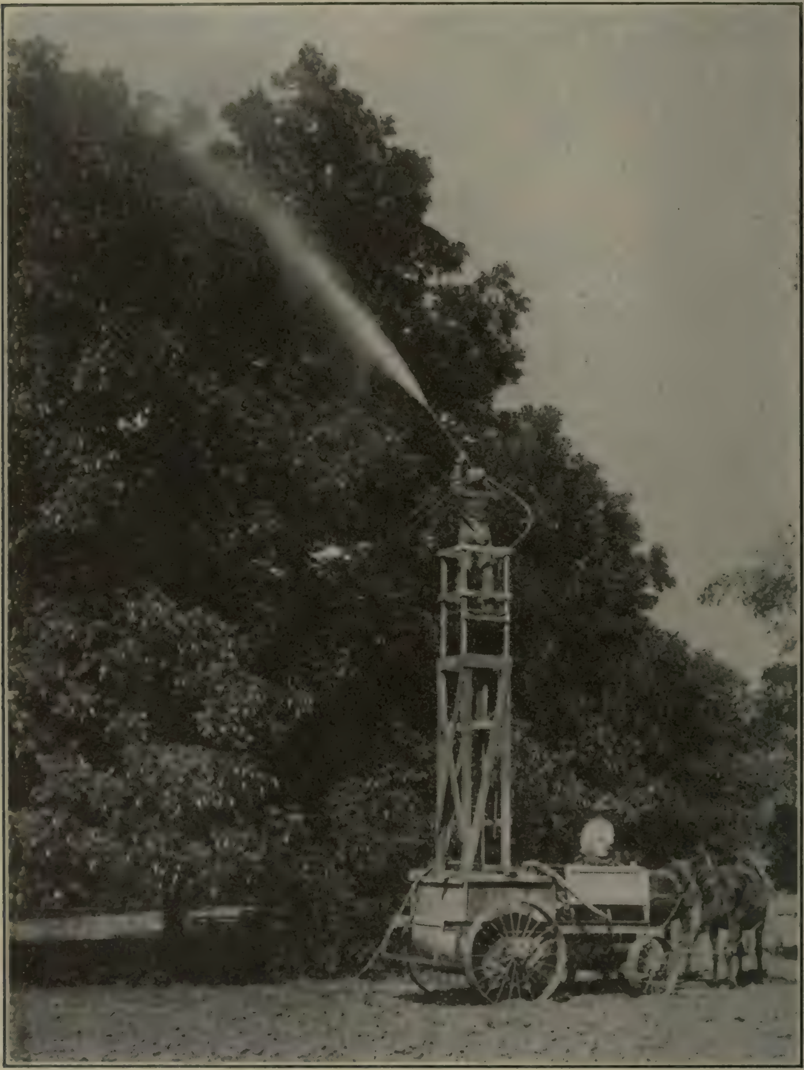

FIGURE 21.—A tower is a necessity when tall pecan trees are sprayed

scab spots appear on the upper portion of the nuts; therefore, spray directed from the top of a tower will furnish better protection than that directed from the ground. Only those nuts that are given a complete coverage of spray are well protected. The man with the long hose on the ground should concern himself chiefly with the leaves and nuts on the lower branches and the inner lower part of the tree. His work is considered important as he can more readily cover the lower side of nuts and leaves of the lower branches. His work is especially valuable in combating foliage diseases, leaf case-bearers, and aphids. The operator in the tower should direct the spray at different horizontal angles as the trees are being passed so that all sides of the nuts may be covered. Spray must be directed from two sides of each tree. The spray machine should be conveyed along one side of the tree row and back along the opposite side. When spraying large pecan trees the machine should pause at least twice in passing a tree so as to give the nozzle operator time to cover all parts within range. The first stop should be made on approaching the tree, and the second may be made just after the center of the tree has been passed. The exact position of the stop in relation to the tree will depend somewhat upon the direction and velocity of the wind, and also on the position of the larger branches on the side being sprayed. The operator should always take advantage of open spaces between the large limbs to spray distant parts of the tree top.

If a large acreage of trees is to be sprayed, much time and expense will be saved if the water and spray materials are conveyed to the spray outfit in a supply tank having a capacity equal to that of the spray tank. This will permit the spray machine to operate continuously except for the short time required to transfer the water from the supply tank to the spray tank. The driver of the spray outfit should be able not only to drive but to keep the motor and pump in working order; he will be all the more valuable if he can exchange places with the man operating the spray gun.

Pecan growers as a rule have attempted to spray too many trees with a limited equipment. As a result the applications have not been well timed; the spray operators have been compelled to sacrifice thoroughness for speed; and the machines are worked to full capacity for days at a time with little attention given to repairs and adjustments. The final outcome has generally been poor control and discouragement.

On account of variable factors, such as age or size of trees, condition and capacity of machines, refilling facilities, and type of labor used, it is not an easy task for the grower to determine the number of trees or the acreage one outfit can spray successfully. However, each grower should certainly possess enough machines to spray his scab-susceptible trees within a week or 10 days at the most.

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U. S. GOVERNMENT PRINTING OFFICE: 1931

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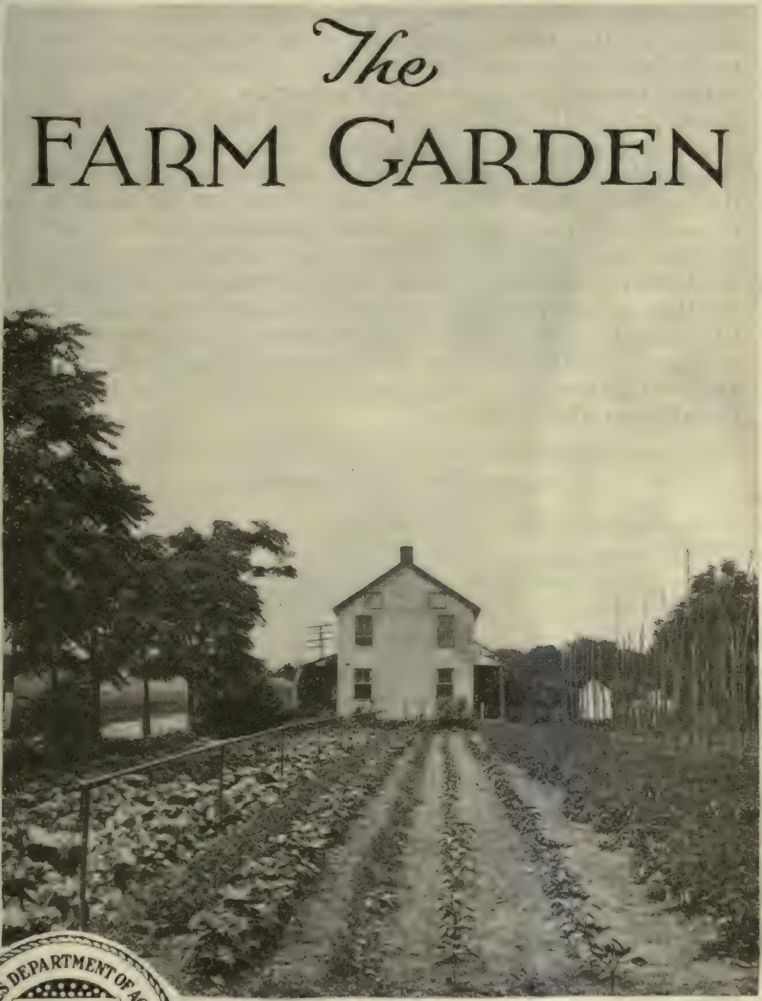
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1673

The FARM GARDEN



FARM GARDENS, maintained on about four-fifths of the farms in the United States as a source of wholesome family food supply, are annually saving millions of dollars for the farmers of the country. A well-cared-for garden will yield a greater return per acre than any similar area on the farm devoted to regular farm crops.

A good garden adds very materially to the well-being of the farm family by supplying foods that might not otherwise be provided. Fresh vegetables direct from the garden are superior in quality to those generally sold on the market, and in addition are readily available when wanted for use.

Certain crops may be grown in southern gardens throughout the winter; in fact, there are thousands of southern farm gardens that produce at least one or two fresh vegetables every day in the year. The northern gardening season may be greatly extended by the use of hotbeds and coldframes and also by planting the more hardy late-summer and fall crops.

This bulletin supersedes Farmers' Bulletins 934, Home Gardening in the South, and 937, The Farm Garden in the North.

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Washington, D. C.

Issued October 1931
Revised August 1936

THE FARM GARDEN

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GENERAL INFORMATION

VALUE OF THE FARM GARDEN

FARM GARDENS are maintained on approximately 79 percent of all farms in the United States, the average value of the products per garden being estimated at $68, or a total of about $350,000,000. A half-acre garden, if properly cared for, will supply vegetables having a market value of at least $100 to $150, sufficient for a family of five or six. The main arguments in favor of a good garden on the farm, however, are that the vegetables are available when needed, are fresh, and have high quality and flavor. These characteristics are not present to the same degree in vegetables bought on the markets, especially those shipped long distances or kept in storage and subjected to handling and exposure.

During busy periods on the farm it is not always possible to go to market for fresh vegetables, and the farm garden becomes a convenient time-saving source of supply. Recent discoveries as to the vitamin content of fresh vegetables, especially the leafy kinds, emphasize the value of the garden in safeguarding the family's health. Crops that require considerable space, such as sweet corn, potatoes, sweetpotatoes, winter squashes, and melons, generally may be grown to best advantage outside the garden and in connection with the cultivation of field crops, leaving the smaller crops to the garden proper.

SOIL AND LOCATION

Good soil is the first essential for a successful garden. The type of soil is not so important as that it be well drained, well supplied with organic matter, retentive of moisture, easy to work, and reasonably free from weeds. Sandy loam soils usually can be worked earlier in the spring than the stiff clay loams, but crops on the clay loams frequently withstand dry weather better than those on the lighter soils. By means of drainage, irrigation, manuring, and the right type of cultivation any reasonably good soil can be made suitable for the intensive production of vegetables.

The slope of the land has considerable influence upon the time when the garden can be planted. A gentle slope toward the south or southeast is favorable for early crops. A location that is protected on the north by a hill, a group of close-growing trees, buildings, a stone wall, or a tight board fence is desirable in sections where winds are likely to cause damage to crops.

Hedges make good windbreaks, but, owing to their heavy shade and draft on soil moisture and plant food, they may prove undesirable in some locations. Arborvitae and California and Amur River privet are most commonly used for hedges around gardens, and if kept closely pruned they are in general fairly satisfactory. In place of a hedge, strips of burlap fastened to the garden fence or to lines of stakes around and through the garden give a fair protection against soil blowing and wind damage. Frequently irrigation is employed to prevent soil blowing and consequent injury to crops. Tightly constructed board fences make good windbreaks for gardens.

Good drainage is essential, and, if possible, the garden should be located on well-drained land. The drainage may often be improved by the addition of tile drains, open ditches, or the loosening of the soil by subsoiling. The garden should be free from depressions in which water might stand after a heavy rain. Waste water from surrounding land should not be allowed to drain upon the garden, and the fall below the garden should be such that there will be no danger of flood water backing up on it. The garden should not be located on creek or river-bottom land subject to overflow during the growing season.

The location of the garden for convenience both in caring for the crops and in gathering the vegetables is of great importance. It should be as near the dwelling as circumstances permit.

Sunlight is a vital factor in the production of vegetables, and for this reason the garden should be situated where it will receive the direct rays of the sun. Certain crops may stand more shading than others, but no amount of fertilizer, water, or care will replace sunshine. Trees not only shade the garden but draw heavily upon the moisture and fertility of the soil. Even where trees are so located that they do not shade the garden, their presence is a menace, for their roots may penetrate far into the garden and rob the crops of moisture and plant food.

PROTECTING THE GARDEN

Under most conditions the garden should be surrounded by a fence sufficiently high and close-woven to keep out poultry, dogs, rabbits, and other animals. In certain sections wild deer frequently destroy gardens, in which case it may be necessary to surround the garden with a fence 8 to 12 feet high. In the Great Plains area jack rabbits are a menace to gardens, but they may be kept out by the use of a rabbit-tight fence. Where the common cottontail rabbit is troublesome, gardens may be protected by either a woven wire or a closely spaced picket fence.

Poultry, especially chickens, are the most common source of injury to farm gardens. Two methods of protection are open to the garden owner—fencing the garden or confining the poultry to a definite inclosure, whichever may be the more desirable or practical. In any event, if crops are to be grown, poultry must be kept out of the garden.

Rodents of various kinds are sources of trouble to garden crops in certain sections of the country. In the East, moles and two or three species of mice cause much injury. They can be controlled by trapping, poisoning, and the use of poisons or repellents placed in their runs. Temporary relief from these rodents can generally be obtained by injecting small quantities of carbon disulphide into their runs. The exhaust gas from an automobile has the same effect. Moth balls dropped into the runs may be effective in driving off moles, but can hardly be depended on as a certain protection. In the West where ground squirrels and prairie dogs are prevalent, poisoning is the usual and most effective remedy.[1]

FERTILIZERS

Stable or barn-lot manure is the best garden fertilizer for use on most soils, except where the land is already oversupplied with organic matter, which is rarely the case. An initial application of 20 large wagonloads of partly rotted manure on a half-acre garden is not excessive. Following this, 8 to 10 tons of manure should be applied each year, unless there is evidence that the soil is becoming too rich in organic matter for certain crops like tomatoes and beans. After this stage is reached, the manure should be applied only to that portion of the garden on which crops that require heavy fertilizing are to be planted. The time of applying the manure will vary, but as a rule it should be spread just before plowing. Inasmuch as the garden is usually planted very shortly after plowing, it is desirable that the manure should be well rotted and rather fine. Coarse or strawy manure not only may interfere with the cultivation of the crops, but does not give as good results as does thoroughly rotted manure. Some farmers follow the practice of first plowing the garden, then spreading several loads of well-composted manure over the surface and working it into the soil with a disk harrow.

The addition of 50 to 80 pounds of superphosphate to each ton of manure, either in the stable or during the composting period, will aid in the decomposition of the manure and also greatly increase its value as a fertilizer. The usual method of composting manure is to place the required quantity in a low, flat pile and turn it once every week or 10 days until it has been turned three or four times. After the third or fourth turning the manure can be allowed to remain in a flat pile until wanted for spreading on the garden. If the manure is dry, water should be added to prevent burning.

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[1] Full information on the poisoning of rodents can be procured from the Bureau of Biological Survey, U. S. Department of Agriculture.

Where large quantities of manure are being hauled from a feed lot to the fields, it is often possible to save a few loads of the finer material or scrapings for use on the garden.

Sheep and goat manures are extensively used in parts of the West and Southwest. On farms where large flocks of poultry are kept there is often a considerable accumulation of poultry manure, which may be used at a rate not exceeding 100 pounds for each 1,000 square feet. It should be borne in mind that sheep, goat, and poultry manures contain a high percentage of nitrogen and therefore should be used sparingly; otherwise injury to crops may occur. This is particularly true when commercial pulverized sheep manure is applied directly around growing plants, and great care must be taken to spread the manure thinly and mix it with the soil rather than to place it in direct contact with the plants. Where poultry, sheep, or goat manure is being used in making hills for cucumbers, melons, or squashes, it should be mixed with the soil to a depth of at least 6 inches over an area 18 to 24 inches in diameter.

SPECIAL FERTILIZERS AND COMPOST

Every farm garden should be provided with a compost pile from which a supply of fine, rich soil for growing plants may be available at all times. The ideal method of making a compost pile is to stack sods or turf with an equal quantity of manure, let the pile rot, then mix and screen for use. It usually requires about a year for material of this kind to rot, and it may be necessary to add a little water from time to time to give it the right degree of moisture for proper decay. Spading or turning the compost heap occasionally will hasten the process of decay, but, as a rule, merely piling the materials together in a heap will give fair results. The manure from the hotbed, sods or rich soil that may be available, and the poultry-house floor cleanings all may go into the compost pile to form soil for use on the garden or for growing early plants. The refuse from garden crops should not go into the compost because of the danger of spreading plant diseases.

Sterilizing the soil used for starting early plants by baking it slowly in the oven for an hour or two not only will greatly reduce the danger of plant losses from soil-borne diseases but will also destroy many of the weed seeds that are present in the soil.

Commercial fertilizers may be used to advantage in many farm gardens, the composition and rate of application depending on the locality, soil, and crops to be grown. For general use, a fertilizer containing 5 percent nitrogen, 10 percent phosphoric acid, and 5 or 6 percent potash will give good results. Leafy crops, such as spinach, cabbage, kale, and lettuce, often require a higher percentage of nitrogen and may be stimulated by side dressings of nitrate of soda or some other form of readily available nitrogen. As a rule the root crops, including beets, carrots, turnips, and parsnips, need a higher percentage of potash. A fertilizer for potatoes may contain as much as 8 or 10 percent of potash in addition to nitrogen and phosphoric acid.

The quantity of fertilizer to use will depend upon the condition of the soil, its natural fertility, and the crops being grown. Tomatoes and beans, for example, do not normally require a great amount of fertilizer, especially nitrogen; whereas onions, celery, lettuce, the root crops, and potatoes will respond to relatively large applications. In some cases 300 pounds of commercial fertilizer may be sufficient on a half-acre garden;[2] in other cases 1,000 or 1,200 pounds can be used to advantage. All depends upon the condition of the soil and its previous treatment, especially with regard to the manure and fertilizers used upon it during the preceding 2 or 3 years.

Commercial fertilizers as a rule should be applied either a few days before planting or at the time the crops are planted. The usual practice is to plow the land and give it its first harrowing, then spread the fertilizer from a pail or with a fertilizer distributor, harrowing the soil two or three times to get it in proper condition and at the same time mixing the fertilizer with it. For crops like potatoes and sweetpotatoes it is customary to scatter the fertilizer in the rows, taking care to mix it thoroughly with the soil before the seed is dropped, or, in the case of sweetpotatoes, before the ridges are thrown up.

The roots of most garden crops spread to considerable distances. The application of fertilizer to the entire area, therefore, will provide a uniform source of food for the plants to feed on. Care must be taken not to place fertilizer too near seedlings or young plants, as burning of the roots is likely to occur. Like caution must be exercised in using nitrate of soda or sulphate of ammonia as a side dressing for growing crops. On a half-acre garden 75 to 100 pounds of any of these concentrated sources of nitrogen is sufficient for one application, and where only a part of the garden is treated the quantity should be regulated accordingly. The fertilizer should be sown alongside the rows and cultivated into the topsoil.

LIME

Lime improves the texture of certain heavy soils, but its excessive use may prove injurious to most garden crops. As a general rule, asparagus, celery, beets, spinach, and sometimes carrots are benefited by the moderate use of lime, especially on soils that are naturally deficient in lime. Most of the garden vegetables do best on soils that are slightly acid, and all vegetables are injured by the application of lime in excess of their requirement. For this reason lime should be applied only where it is definitely shown by actual test to be necessary, and in no case should it be applied in large quantities. As a matter of fact most garden soils in a state of high fertility do not require the addition of lime. With good drainage, plenty of manure in the soil, and the moderate use of commercial fertilizers, the growth requirements of nearly all vegetables may be fully met.

Where lime is applied, it should be spread after plowing and be well mixed with the topsoil by harrowing. It should not be applied at the same time as, or mixed with, commercial fertilizers or manure, as the chemical changes that take place result in the loss of nitrogen and thus destroy the effectiveness of the fertilizers. As a rule, lime should not be applied in the fall, as it leaches from the soil during the winter. Any of the various forms of lime, such as hydrated lime and air-slaked lime, may be used. In some cases the unburned but finely ground limerock is used, but its action is slower than that of the burned lime. Finely ground oyster shells and marl are frequently used as substitutes for lime. Owing to its influence on the development of potato scab, lime should not be used on land that is being planted to potatoes.

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[2] There are 43,560 square feet in an acre, or an area each of the four sides of which measures approximately 208½ feet. A piece of land 208 feet in length and 105 feet in width will contain practically ½ acre. A piece of land 220 feet in length and 100 feet in width will also contain practically ½ acre.

SOIL PREPARATION

The time and method of preparing the garden for planting depend on the type of soil and location. Heavy clay soils in the northern sections are frequently benefited by fall plowing and exposure to freezing and thawing during the winter. Gardens in the dry-land areas should be plowed and leveled in the fall, so that the soil will absorb and retain all moisture that falls during the winter. The sandy soils of the South as a rule should not be plowed until near the time of planting. Wherever there is a heavy growth of crabgrass or a green cover crop the land should be plowed well in advance of planting and the soil disked several times to aid in the decay and incorporation of this material. Soils on which gardens are ordinarily planted should not be plowed or worked while wet. Sandy soils generally bear plowing a trifle sooner than heavy clay soils. The usual test is to squeeze together a handful of soil. If it adheres in a ball and does not readily crumble when slight pressure is exerted by the thumb and finger, it is too wet for plowing or working.

Fall-plowed land may be prepared as a rule by disking and harrowing. Spring-plowed land should be harrowed immediately after plowing, and if the soil is inclined to be lumpy a plank drag or a roller should be used for pulverizing it. Seeds grow more readily on a fine well-prepared soil than on a course or lumpy one, and thorough preparation greatly reduces the work of planting and caring for the crops. Spading is sometimes advisable in preparing small areas, such as beds for extra early crops of lettuce, onions, beets, and carrots, but the main portion of the garden should be plowed and harrowed. As a rule the tools ordinarily used on the farm will be suitable for preparing the garden for planting. In laying out the garden provision should be made for a gate or opening through which to haul manure or to bring in teams or a tractor as well as the tools for preparing and cultivating the garden.

PLAN AND ARRANGEMENT

It would be difficult to give a plan or specific arrangement for a garden that would suit all demands. Such a plan must be devised by each individual grower. Suggestive arrangements, however, are here presented, with the idea that they can readily be changed to suit local conditions.

The first consideration in planning the arrangement of a garden is the kind of cultivation that is to be employed. When the work is to be done mainly by means of horse tools the site and the arrangement should be such as to give the longest possible rows, and straight lines should be followed (fig. 1). The garden should be free from

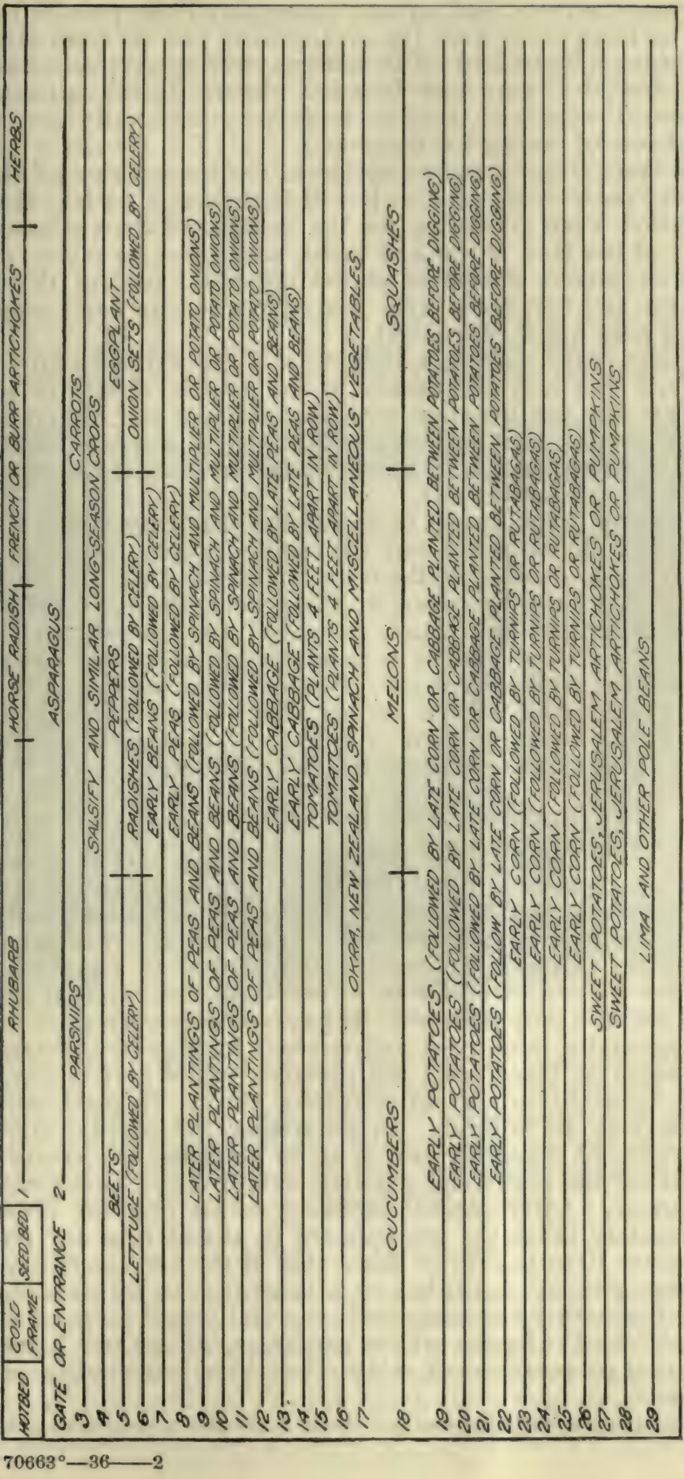
HOTBED
COLD FRAME
SEED BED
1
RHUBARB
HORSE RADISH
FRENCH OR BURR ARTICHOKES
HERBS
GATE OR ENTRANCE
2
ASPARAGUS
3
PARSNIPS
CARROTS
4
SALSIFY AND SIMILAR LONG-SEASON CROPS
5
BEETS
PEPPERS
EGGPLANT
6
LETTUCE (FOLLOWED BY CELERY)
RADISHES (FOLLOWED BY CELERY)
ONION SETS (FOLLOWED BY CELERY)
7
EARLY BEANS (FOLLOWED BY CELERY)
8
EARLY PEAS (FOLLOWED BY CELERY)
9
LATER PLANTINGS OF PEAS AND BEANS (FOLLOWED BY SPINACH AND MULTIPLIER OR POTATO ONIONS)
10
LATER PLANTINGS OF PEAS AND BEANS (FOLLOWED BY SPINACH AND MULTIPLIER OR POTATO ONIONS)
11
LATER PLANTINGS OF PEAS AND BEANS (FOLLOWED BY SPINACH AND MULTIPLIER OR POTATO ONIONS)
12
LATER PLANTINGS OF PEAS AND BEANS (FOLLOWED BY SPINACH AND MULTIPLIER OR POTATO ONIONS)
13
EARLY CABBAGE (FOLLOWED BY LATE PEAS AND BEANS)
14
EARLY CABBAGE (FOLLOWED BY LATE PEAS AND BEANS)
15
TOMATOES (PLANTS 4 FEET APART IN ROW)
16
TOMATOES (PLANTS 4 FEET APART IN ROW)
17
OKRA, NEW ZEALAND SPINACH AND MISCELLANEOUS VEGETABLES
18
CUCUMBERS
MELONS
SQUASHES
19
EARLY POTATOES (FOLLOWED BY LATE CORN OR CABBAGE PLANTED BETWEEN POTATOES BEFORE DIGGING)
20
EARLY POTATOES (FOLLOWED BY LATE CORN OR CABBAGE PLANTED BETWEEN POTATOES BEFORE DIGGING)
21
EARLY POTATOES (FOLLOWED BY LATE CORN OR CABBAGE PLANTED BETWEEN POTATOES BEFORE DIGGING)
22
EARLY POTATOES (FOLLOW BY LATE CORN OR CABBAGE PLANTED BETWEEN POTATOES BEFORE DIGGING)
23
EARLY CORN (FOLLOWED BY TURNIPS OR RUTABAGAS)
24
EARLY CORN (FOLLOWED BY TURNIPS OR RUTABAGAS)
25
EARLY CORN (FOLLOWED BY TURNIPS OR RUTABAGAS)
26
EARLY CORN (FOLLOWED BY TURNIPS OR RUTABAGAS)
27
SWEET POTATOES, JERUSALEM ARTICHOKES OR PUMPKINS
28
SWEET POTATOES, JERUSALEM ARTICHOKES OR PUMPKINS
29
LIMA AND OTHER POLE BEANS

FIGURE 1.—Plan of a half-acre garden. Length, 200 feet; width, 100 feet. A half-acre garden will produce all the vegetables the average family can use throughout the growing season and a surplus for canning, storing, and drying.

paths across the rows, and turning spaces should be provided at the ends. For hand cultivation the arrangement can be quite different, as the garden may be laid off in sections, wth transverse walks, and the rows for most crops may be much closer. Horse cultivation is recommended whenever possible, as it very materially lessens the labor and cost of caring for the crops.

Where there is any great variation in the composition of the soil in different parts of the garden it will be advisable to take this into consideration when arranging for the location of the various crops. If a part of the land is low and moist, such crops as celery, onions, and late cucumbers should be placed there. If part of the soil is high, warm, and dry, there is the proper location for early crops and those that need quick, warm soil.

Permanent crops, such as asparagus and rhubarb, also any of the small fruits that may be planted in the garden, should be located where they will not interfere with the plowing and cultivation of the annual crops. If a hotbed, a coldframe, or a special seedbed is provided, it should be either in one corner of the garden or located outside of the garden entirely.

Tall-growing crops should be so located that they will not shade or interfere with the growth of the smaller crops. There seems to be little choice as to whether the rows run east and west or north and south, but they should conform to the general shape of the garden with convenience of cultivation in mind. In general, the smaller crops, especially those worked by hand, should be located nearest the house, with the larger crops like potatoes, sweet corn, and the vine crops in that portion of the garden most distant from the house. However, the general location of crops will depend largely on the character of the soil and convenience in cultivating.

SEED SUPPLY

Seeds for the farm garden should be ordered well in advance of planting time. Make a plan (fig. 1) of the garden, indicating the space each crop is to have, and order the seeds accordingly, allowing for replanting in case of a poor stand due to adverse weather conditions or other causes.[3] In making the plan it is a good idea to measure the garden carefully to be sure that the required space is available for each crop included. It pays to use garden seeds of high quality, especially those bred and selected for disease resistance.

Seeds saved at home from the previous year's garden should be carefully inspected so that in case they are not in good condition fresh ones may be ordered. In estimating the supply, allowance should always be made for two or more plantings of certain vegetables and for the tastes and requirements of the different members of the family. After careful checking to see that the order has been completely filled, the seeds should be stored in a dry place at a temperature 10 to 15 degrees below that of the average living room until planting time. A tin box or a large tin can makes a suitable container for storing vegetable seeds, especially as it gives protection from mice. Seeds of many of the garden vegetables will keep from 4 to 6 years if properly stored, while others lose their vitality quickly.

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[3] The approximate quantities of seed that should be provided for planting a garden to supply vegetables for a family of five or six persons are given in the table on page 22.

STARTING EARLY PLANTS

Under southern conditions practically all vegetable plants may be started in specially prepared beds in the open with little or no covering. In the middle section and throughout the North and West, if an early garden is desired, it is essential that certain crops such as tomatoes, peppers, eggplant, cabbage, and cauliflower, and occasionally lettuce, onions, beets, cucumbers, squashes, and melons, be started indoors or in coldframes.

THE SEED BOX IN THE HOUSE

The simplest method of growing early plants is to provide a flat tray or box, such as is shown in figure 2, which may be fitted into a south window of any room that is kept reasonably warm. Fill this box with sifted soil, and in it sow the seeds of tomato, eggplant, peppers, and cabbage. When the plants are 10 to 20 days old, they can be transplanted to other boxes filled with reasonably rich sifted soil from the compost pile. Plants grown in this manner in the house, however, are inclined to be spindling, and better results may be obtained where a hotbed or a coldframe is employed.

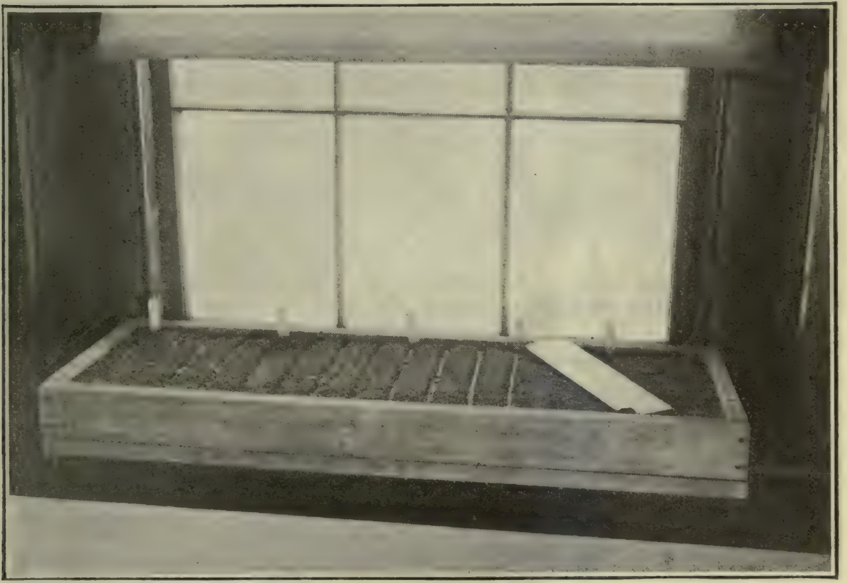

FIGURE 2.—Window box for starting early plants in the house.

HOTBEDS AND COLDFRAMES

In the South the hotbed will not be necessary as a rule, but a coldframe or sash-covered pit on the south side of a building will be found satisfactory for starting the early plants. In colder sections some form of heat is essential, and a manure-heated hotbed is usually the best type to provide. In the North the hotbed should be started in February or early in March, in order that the plants may be well grown in time to plant in the open ground.

The hotbed should always face the south and should be located on the south side of a building, a tight board fence, or a protecting wall, preferably near the house, where it can be given proper attention. A hotbed consists of a pit about 18 inches deep filled with fermenting horse-stable manure to furnish the heat. Material that is about half manure and half straw bedding is desirable. Place the manure in a low, flat pile, and turn it over once or twice as it begins to heat, in order to have it uniform; then place it in the hotbed pit in thin layers, shaking the manure out loosely as it is spread. Each successive layer, as it is put in, should be well trampled, and, if dry, a small quantity of water added so that the manure will pack solidly in the pit.

After the manure has been properly leveled and trampled in the bed, the frame to support the sash is placed in position. Generally the frame is made to carry four or five standard hotbed sash, or where only a small bed is required, one to three sash. The front or south side of the frame should be 8 to 12 inches lower than the back, in order to get the greatest benefit from the sunlight and so that water will drain from the glass. From 3 to 5 inches of good screened garden loam or specially prepared soil from the compost heap is then spread evenly over the manure in the frame, the sash are put on, and the bed is allowed to heat. At first the temperature of the bed will run somewhat high, but no seeds should be planted until the soil temperature falls below 80° F., which in most cases will be in about 3 or 4 days. It is not safe to judge the temperature by feeling the soil with the hand. A thermometer, its bulb buried in the soil, is the best means of telling when the bed falls to the proper temperature.

Standard hotbed sash in common use are 3 by 6 feet, containing 3 to 5 rows of glass. The sash may be purchased unpainted and unglazed or fully painted and filled with glass as desired. They should have at least two coats of paint consisting of white lead and linseed oil. In glazing the sash the glass should be bedded in putty, the panes overlapping about one-fourth inch and fastened securely in place with zinc glazing nails made for the purpose. No putty should be placed on the surface of the glass, the glass being simply bedded in putty and all surplus putty trimmed off.

In the colder parts of the country, board shutters, straw, or burlap mats, in addition to the sash, will be required as a covering during cold nights. It is also desirable to have a supply of straw or loose manure on hand to throw over the bed in extremely cold weather.

On bright days, when the hotbed heats very quickly from the sunshine on the glass, the sash should be raised slightly on the side opposite from the wind. In ventilating, care should be taken to protect the plants from a direct draft of cold air. Toward evening the sash should be closed, in order that the bed may become sufficiently warm before nightfall. Hotbeds should be watered on bright days, preferably in the morning. If it is necessary to water late in the day, the sash should be left open for a short time until the plants dry off. Plants grown in hotbeds are frequently lost by a disease known as damping off, which can be largely prevented by careful watering and proper ventilation.

Coldframes are constructed like hotbeds, except that no manure or other heating material is used (fig. 3). They are covered with ordinary hotbed sash, but cotton cloth may be substituted for the sash. In the South coldframes are used for growing early plants; in the North they are used for hardening off plants that have been started in hotbeds or in the house. The same general rules for the care of a hotbed apply to a coldframe, but the latter is usually ventilated more freely. Toward the close of the plant-growing period the sash or cloth covering of the frame may be left off entirely, to adapt the plants to outdoor conditions, but the covering should be kept near by in case of a sudden drop in temperature.

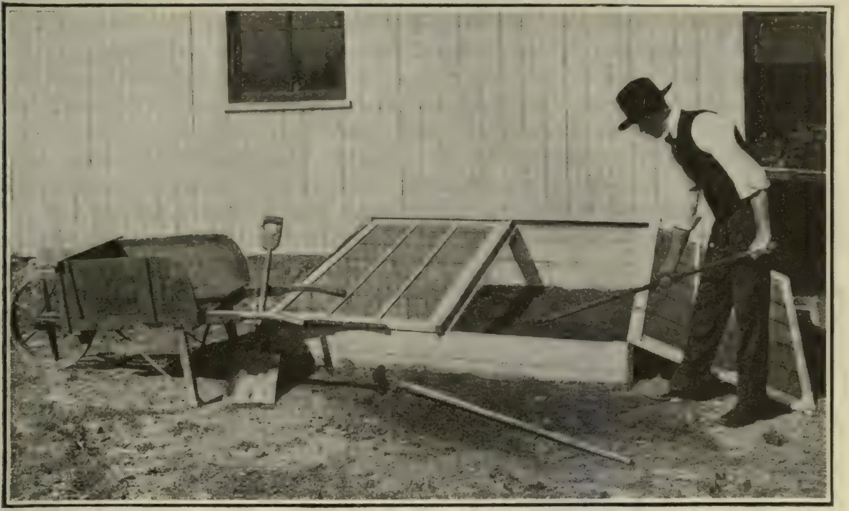

FIGURE 3.—A sash-covered frame (coldframe) for starting early plants.

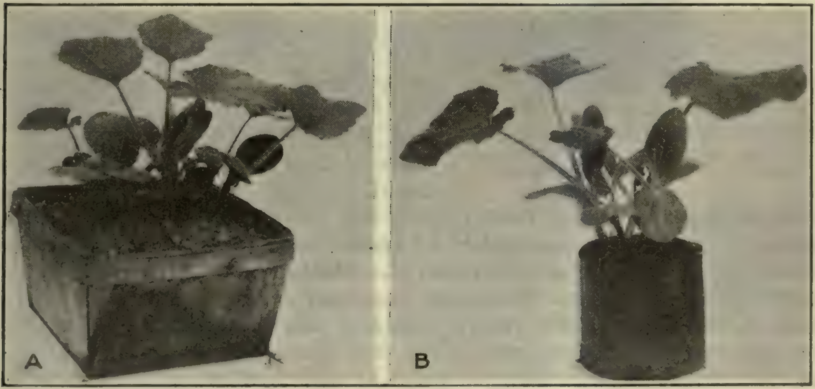

FIGURE 4.—Methods of starting early plants for the garden indoors by the use of (A) quart berry boxes and (B) paper bands.

SPECIAL METHODS FOR STARTING EARLY PLANTS

Early plants for the garden may be started indoors in quart berry boxes (fig. 4, A), paper drinking cups, paper bands (fig. 4, B), or in regular clay flowerpots. The containers are filled with sifted soil and placed in the hotbed, or if in the house they are placed in a shallow box. A small amount of seed is sown in each container, and after the plants are well under way they are transferred to the garden, the container usually being removed from about the roots of the plants when set in the planting hole. In the case of clay flowerpots the ball of earth containing the roots is simply jarred loose and removed from the pot. Soft paper bands or peat pots need not be removed, the roots of the plants being simply allowed to grow through the container and into the soil about them.

Market gardeners generally spot the plants in the hotbed or coldframe 4 or 5 inches apart in each direction. In moving them to the garden a knife is run to a depth of 4 or 5 inches in each direction between the plants, cutting the soil in blocks as shown in figure 5. Each block, with the plant in its center, is removed direct to the garden. Plants moved in this manner should be watered when set, unless the soil is very moist.

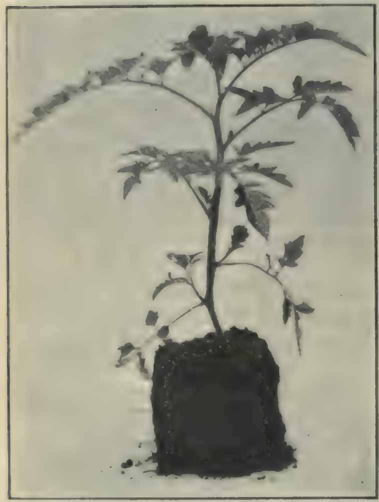

FIGURE 5.—Tomato plant for the early garden, grown in hotbed or coldframe by the blocking method.

SOUTHERN-GROWN PLANTS

Southern vegetable plants grown in the open and shipped to all parts of the country are now to a considerable degree taking the place of the plants formerly grown locally in hotbeds, coldframes, and special seedbeds. These plants are grown very cheaply and withstand transplanting remarkably well. They may not in all cases be as good as home-grown plants, but they save the trouble of starting plants in the house or in a hotbed, and when planted they usually grow very rapidly. The disadvantages of using these plants are the occasional delay in obtaining them and the possibility of transmitting certain diseases, such as the wilt disease of the tomato, black rot of cabbage, and diseases caused by nematodes, which are common on various crops in the South. Southern-grown plants are now offered for sale by most of the northern seedsmen and often by local hardware and supply houses.

TRANSPLANTING

Plants started in the house or in hotbeds should be transplanted to give them more room about the time the first true leaves are formed. The small plants may be transplanted to flat boxes or to the coldframe to stand 2 or 5 inches apart each way. Where clay flowerpots or any of the containers mentioned are used, and a single plant is set in each container, excellent early plants may be grown, with the advantage that the roots will not be disturbed when they are set in the garden. Toward the end of the protected period the plants should be exposed more and more to outdoor conditions. Such plants usually withstand transfer to the garden with little check and few losses. Plants while undergoing the hardening process should be watered sparingly, but just before they are moved to the garden they should be given a thorough watering.

When the time comes to set the plants in the open ground, everything should be in readiness, the soil in good condition, and water available for watering the plants in case there is not enough moisture in the soil. Plants grown in the coldframe or in specially prepared seedbeds should be lifted carefully with a trowel or a spade, as much soil being kept on their roots as possible. Plants do best if moved on a cloudy day or just before a rain, or late in the evening. In using water when setting out plants, first set the plant in the hole and partly fill the hole with soil; next apply the water, allowing it to soak well into the soil. Then fill around the plant with the drier soil, and firm it about the plants. Plants set in this manner seldom wilt. When setting a small number of plants in the garden during a dry period it is often possible to protect them from the midday sun by setting a shingle or a small piece of board at a slant on the south side of each plant. If the plants are protected thus for two or three days after setting, few of them will be lost.

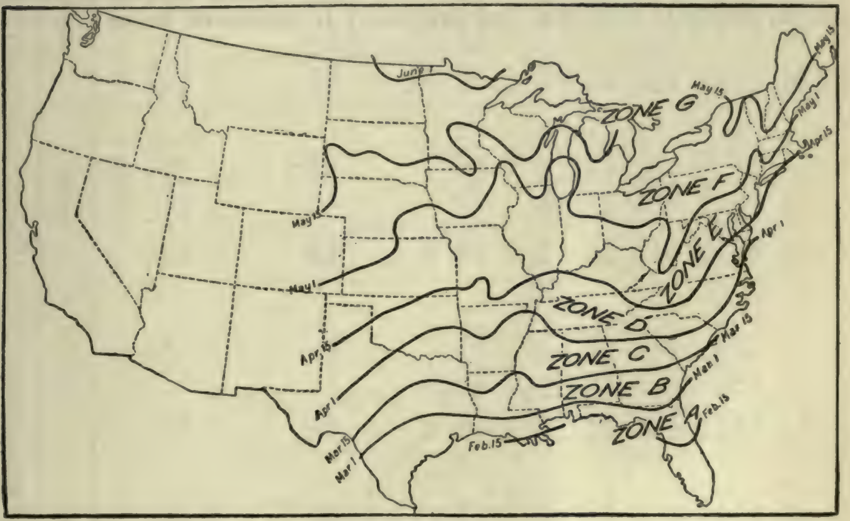

FIGURE 6.—A zone map of the United States, based on the average dates of the latest killing frost in spring east of the Rocky Mountains.

Cabbage and other vegetable plants that are moved direct from the seedbed should be carefully lifted by running a trowel or a spade beneath them, as much soil as possible being left on their roots. Plants handled in this manner should be set either when there is an abundance of moisture in the soil or just before a rain, with the soil firmly packed about their roots. If the soil is dry, a pint or more of water should be poured about the roots of each plant.

TIME OF PLANTING

The earliest dates for planting the various vegetables depend upon the locality, beginning during December or January in the extreme South and following the advance of the season northward until approximately June 10 in the extreme North. Garden crops may be divided into four groups: Crops that can be planted before the time of the last killing frost in the spring, those that can be planted about the time the last killing frost is expected, those that cannot be planted until danger of frost is past, and those that cannot be planted until the ground and the weather are warm. The zone map shown in figure 6 is applicable to that portion of the United States east of the Rocky Mountains and is based on the dates of the last killing frost in the spring. This map and table 1 furnish a reasonably safe guide, although conditions may vary from year to year. There is also a difference of several days within the zones themselves, owing to elevation and proximity to bodies of water.

TABLE 1.—*Earliest safe dates for planting vegetable seeds in the open in the zones of the United States illustrated in figure 6*

Crop	Zone A	Zone B	Zone C	Zone D	Zone E	Zone F	Zone G
Asparagus		Feb. 1 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to 15	May 15 to June 1.
Beans:							
Lima	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	May 1 to 15	May 15 to June 1	May 15 to June 15	
Snap	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to 30	Apr. 1 to May 1	May 1 to 15	May 15 to June 1	May 15 to June 15.
Beet	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr 15	Apr. 15 to May 1	May 1 to 15	May 15 to June 1.
Broccoli:							
Heading [1]	Jan. 1 to Feb. 1	Jan. 15 to Feb. 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to 15.
Sprouting [1]	do	do	do	do	do	do	Do.
Brussels sprouts	do	do	do	do	do	do	Do.
Cabbage	do	do	do	do	do	do	Do.
Cabbage, Chinese	do	do	do	do	do	do	Do.
Cardoon	do	do	do	do	do	do	Do.
Carrot	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 15 to May 1	May 1 to 15	May 1 to June 1.
Cauliflower [1]	Jan. 1 to Feb. 1	Jan. 15 to Feb. 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to 15.
Celeriac	do	do	do	do	do	do	Do.
Celery [1]	do	do	do	do	do	do	Do.
Chard	do	do	do	do	do	do	Do.
Chervil	do	do	do	do	do	do	Do.
Chicory, witloof					June 1 to 15	June 15 to July 1	June 15 to July 1.
Chives	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 1 to May 1	May 1 to 15.
Collards [1]	do	do	do	do	do	do	Do.
Corn salad	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Corn, sweet	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to May 1	Apr. 15 to May 15	May 1 to June 1	May 15 to June 15.
Cress:							
Upland	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Water	do	do	do	do	do	do	Do.
Cucumber	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	Apr. 15 to May 1	May 1 to June 1	May 15 to June 15	June 1 to 15.
Dandelion	Jan. 1 to Feb. 1	Jan. 15 to Feb. 15	Feb. 1 to Mar. 15				
Dasheen	Mar. 1 to Apr. 1	Mar. 15 to Apr. 15	Apr. 15 to May 15				
Eggplant [1]	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	Apr. 15 to May 1	May 1 to June 1	May 15 to June 15	Do.
Endive	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Florence fennel	do	do	do	do	do	do	Do.
Garlic	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 1 to May 1	May 1 to 15.
Horseradish [1]			Mar. 15 to Apr. 1	Apr. 1 to 15	Apr. 15 to May 1	May 1 to 15	May 15 to June 1.
Jerusalem artichoke	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to June 1.
Kale	do	do	do	do	do	do	Do.
Kohlrabi	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Leek	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 1 to May 1	May 1 to 15.
Lettuce	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Martynia	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	Apr. 15 to May 1	May 1 to June 1	June 1 to 15	
Muskmelon	do	do	do	do	do	do	June 1 to 15.
Mustard	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Okra	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to 30	Apr. 15 to May 1	May 1 to 15	May 15 to June 1	

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[1] Plants.

TABLE 1.—*Earliest safe dates for planting vegetable seeds in the open in the zones of the United States illustrated in figure 6*—Continued

Crop	Zone A	Zone B	Zone C	Zone D	Zone E	Zone F	Zone G
Onion:							
Plants	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 1 to May 1	May 1 to 15.
Seed	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Sets	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 1 to May 1	May 1 to 15.
Parsley	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to May 1	May 1 to 15	May 15 to June 1.
Parsley, turnip-rooted	do	do	do	do	do	do	Do.
Parsnip	do	do	do	do	do	do	Do.
Peas	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to June 1.
Peppers [1]	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	Apr. 15 to May 1	May 1 to June 1	June 1 to 15	
Physalis	do	do	do	do	do	do	June 1 to 15.
Poke				Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 1 to May 1	May 1 to 15.
Potato	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	do	do	Apr. 15 to May 1	May 1 to June 1.
Pumpkin	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	Apr. 15 to May 1	May 1 to June 1	June 1 to 15	
Radish	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to 15.
Rhubarb [1]				Mar. 15 to Apr. 15	Apr. 1 to May 1	Apr. 15 to May 15	May 1 to June 1.
Salsify	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	do	Apr. 15 to May 1	May 1 to 15	May 15 to June 1.
Shallots	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 1 to May 1	May 1 to 15.
Sorrel	Feb. 1 to Mar. 1	Feb. 15 to Mar. 15	Mar. 1 to Apr. 1	Mar. 1 to Apr. 1	Apr. 1 to 15	Apr. 15 to May 1	Do.
Spinach	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	do	Mar. 15 to Apr. 15	do	May 1 to 15.
Spinach, New Zealand	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	May 1 to 15	May 15 to June 1	May 15 to June 15	
Squash	do	do	do	Apr. 15 to May 1	May 1 to June 1	June 1 to 15	June 1 to 15.
Sweet potato [1]	do	do	do	do	do	do	
Tomato [1]	do	do	do	do	do	do	June 15 to 30.
Turnip greens	Jan. 1 to Feb. 1	Feb. 1 to 15	Feb. 15 to Mar. 1	Mar. 1 to 15	Mar. 15 to Apr. 15	Apr. 15 to May 1	May 1 to 15.
Turnips and rutabagas	do	do	do	do	do	do	Do.
Watermelon	Mar. 1 to 15	Mar. 15 to Apr. 1	Apr. 1 to 15	Apr. 15 to May 1	May 1 to June 1	June 1 to 15	

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[1] Plants.

By referring to figure 7 it will be noted that the dates when the last killing frost may be expected in the western part of the country are extremely variable. For example, at certain points in Colorado this date is as late as June 12 or 16; at points in Wyoming to the northward it is as early as May 4; in California there is a variation from January 25 to June 22; and in Arizona, from February 15 to June 27. Primarily these variations are owing to differences in the elevations of the stations where the observations were made rather than to the location of the stations in different zones.

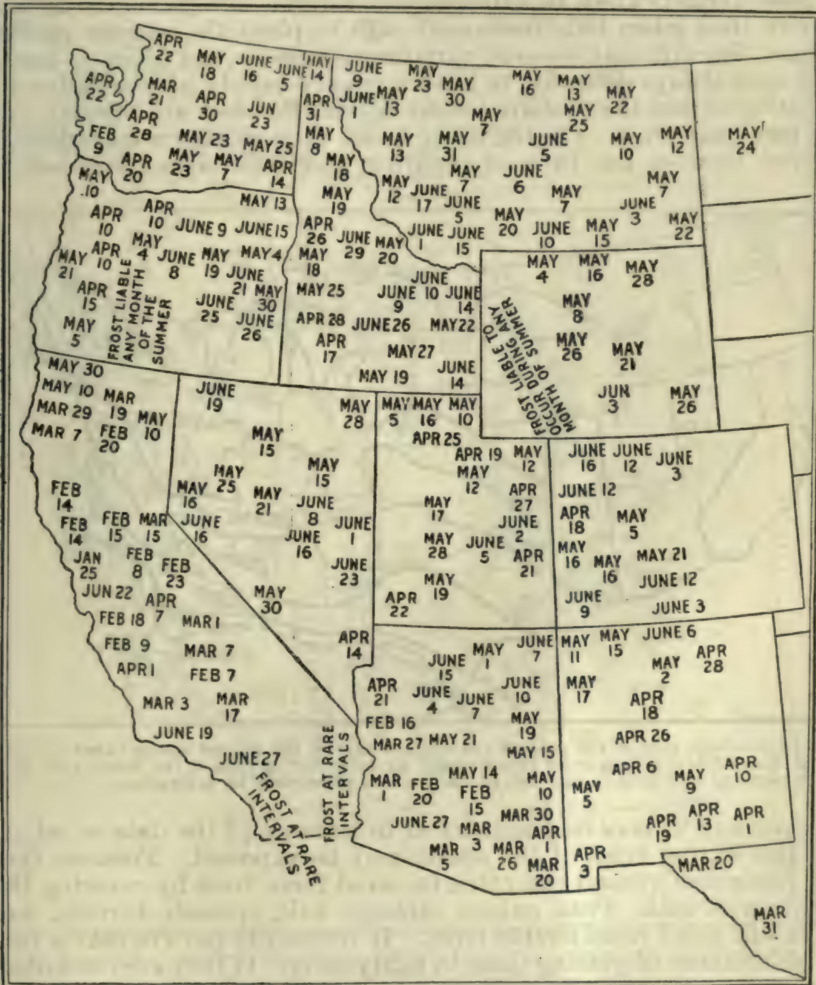

FIGURE 7.—Outline map showing the average date of the last killing frost in spring in the western portion of the United States.

Of equal importance are the latest dates on which various crops may be planted and yet mature before the earliest killing frost in the autumn. The zone map shown in figure 8 gives the approximate dates of the earliest autumn frosts in the central and eastern part of the United States, while the outline map shown in figure 9 gives this information for the Rocky Mountain and Pacific coast regions. It will be noted that in the latter area there is one section where frost rarely ever occurs and two sections where frost is liable to occur during any month of the year. By referring to table 2 the approximate latest date for planting any given crop may be determined.

Most farmers know by experience and by the blossoming of certain native trees when it is reasonably safe to plant the various garden crops. Exceptional seasonal variations, however, are likely to occur, and it is always desirable to have a reserve supply of plants for replanting in case the first are lost by frost. Potatoes are injured even by moderate frost. On the other hand, they require a considerable period between the time of planting and their appearance above ground, and so may be planted well in advance of the date on which the last killing frost of the season may be expected. Potatoes that are just above ground can often be saved from frost by covering the plants with soil. Peas, onions, cabbage, kale, spinach, turnips, and beets will stand considerable frost. It frequently pays to take a reasonable chance of putting them in fairly early. If they are not killed, it means early vegetables; if they are, nothing is lost but the seed and the labor of replanting. Summer squashes, cucumbers, and melons frequently may be planted in advance of their normal season, the hills being protected from wind and frost by paper or glass covers. In addition these covers protect the plants from insects.

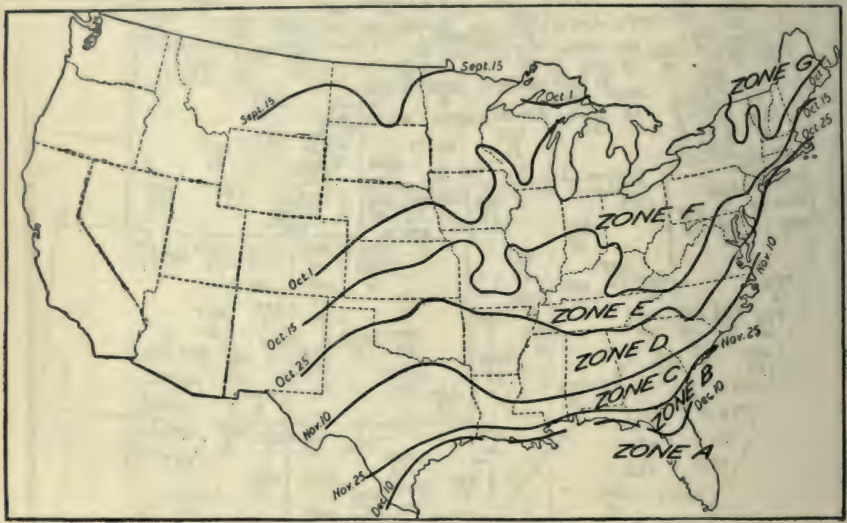

FIGURE 8.—Zone map of the central and eastern part of the United States based on average date of first killing frost in autumn. By referring to table 2 the latest safe date for planting any crop in any one of the various zones may be determined.

PLANTING THE GARDEN

Methods of planting garden crops vary with the locality and the type of soil. In some sections of the South, especially along the

South Atlantic coast and in the Gulf States, it may be necessary to plant in beds or ridges in order to obtain good drainage. Level planting is recommended on the lighter sandy soils and on the majority of the sandy loam and clay loam soils of the North and Northeast. In the irrigated sections of the West the seeds are usually planted on the side of the furrows a little above the irrigation water level. In all cases the method of planting should conform to the approved customs of the region and the type of soil upon which the garden is located.

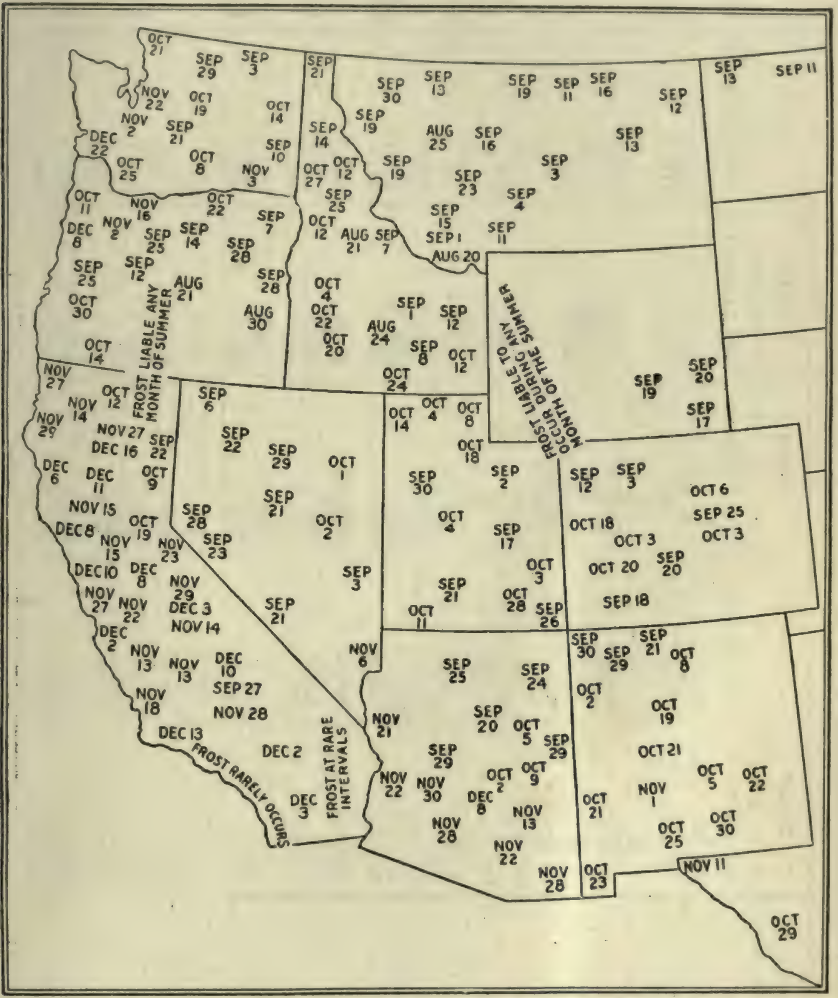

FIGURE 9.—Outline map showing average date of the killing frost in the autumn in the western portion of the United States.

TABLE 2.—*Latest safe dates for planting vegetable seeds and plants in the open in the zones of the United States illustrated in figure 8*

Crop	Zone A	Zone B	Zone C	Zone D	Zone E	Zone F	Zone G
Asparagus		Nov. 1 to Dec. 1	Nov. 1 to Dec. 1	Nov. 1 to Dec. 1	Nov. 1 to Dec. 1	Oct. 15 to Nov. 15.	Oct. 1 to Nov. 1.
Beans:							
Lima	Oct. 1	Oct. 15	Sept. 1				
Snap	do	do	do	Aug. 15	Aug. 1	Aug. 15	Aug. 15.
Beet	Nov. 1	Oct. 1	do	do	do	July 15	July 1.
Broccoli:							
Heading [1]	do	do	do	do			
Sprouting [1]	do	do	do	do	Aug. 1	July 15	Do.
Brussels sprouts	do	do	do	do	do	do	Do.
Cabbage [1]	do	do	do	do	do	do	Do.
Cabbage, Chinese	do	do	Oct. 1	Sept. 1	July 15	Aug. 1	Do.
Cardoon	do	do	Sept. 1	Aug. 15	Aug. 1	July 15	Do.
Carrot	do	do	do	do	do	do	Do.
Cauliflower [1]	do	do	do	do	do	do	Do.
Celeriac			Oct. 1	Sept. 1	Aug. 1	July 1	Do.
Celery [1]	Nov. 1	Oct. 1	do	do	July 15	do	June 15.
Chard	do	do	do	do	do	do	Do.
Chervil	do	do	do	do	do		
Chicory, witloof	Dec. 1	Nov. 1	do	Aug. 15			
Chives				July 1	June 15	June 1	May 15.
Collards [1]	Nov. 1	Oct. 1	Sept. 1	Aug. 15	July 15	July 1	June 1.
Corn salad	Dec. 1	Nov. 15	Nov. 1	Oct. 1	Sept. 15	Aug. 15	July 15.
Corn, sweet	Oct. 1	Sept. 1	Aug. 15	Aug. 1	July 15	July 1	June 15.
Cress:							
Upland	Dec. 1	Nov. 15	Nov. 1	Oct. 15	Oct. 1	Sept. 1	
Water	do	do	do	do	do	do	
Cucumber			Aug. 15	Aug. 1	July 15	July 1	June 1.
Dandelion	Dec. 1	Nov. 1	Oct. 15	Oct. 1	Sept. 15	Sept. 1	
Dasheen [2]							
Eggplant [1]	Sept. 1		July 15	July 1	June 15	June 1	
Endive	Nov. 1	Nov. 1	Nov. 1	Oct. 15	Oct. 1	Sept. 1	Aug. 1.
Florence fennel			Oct. 1	Sept. 1	Aug. 1	July 1	July 1.
Garlic [2]							
Horseradish [1]							
Jerusalem artichoke							
Kale	Nov. 1	Nov. 1	Nov. 1	Oct. 1	Sept. 15	July 1	Do.
Kohlrabi	do	Oct. 1	Sept. 1	Aug. 15	July 15	do	June 15.
Leek	do	do	do	July 1	June 15	June 1	May 15.
Lettuce	Dec. 1	Nov. 1	Oct. 1	Sept. 1	Aug. 1	July 15	July 1.
Martynia	Nov. 15	do	Oct. 15	Oct. 1	Sept. 1	Aug. 1	July 15.
Muskmelon [2]							
Mustard	Dec. 1	Nov. 15	Nov. 1	Oct. 15	Oct. 1	Sept. 1	Aug. 15.
Okra	Oct. 1	Sept. 15	July 15	July 1	June 15		

Onion:							
Plants	Dec. 15	Dec. 1	do	do	do	June 1	May 15.
Seed	Dec. 1	Nov. 1	Oct. 15				
Sets	Dec. 15	Dec. 1	July 15	July 1	June 15	June 1	Do.
Parsley	Dec. 1	Nov. 1	Nov. 1	Sept. 1	Aug. 1	July 15	July 1.
Parsley, turnip-rooted	do	Nov. 15	do	do	July 1	June 15	Do.
Parsnip	do	Nov. 1	June 15	June 1			
Peas	Nov. 1	Oct. 1	Sept. 1	Aug. 15	Aug. 15	Aug. 15	Aug. 15.
Peppers[1]	Sept. 15	Sept. 1	July 15	July 1	June 15	June 1	
Physalis	Sept. 1	do	Aug. 15	July 15	July 1	do	
Poke[2]							
Potato	Sept. 15	Sept. 1	Aug. 15	Aug. 1	July 15	July 1	June 15.
Pumpkin	do	do	do	do	do	do	Do.
Radish	Dec. 1	Nov. 1	Oct. 15	Oct. 1	Sept. 15	Sept. 1	Aug. 15.
Rhubarb[1]				Nov. 1	Nov. 1	Nov. 1	Nov. 1.
Rutabagas	Nov. 15	Nov. 1			July 1	June 15	June 1.
Salsify	Dec. 1	do	June 15	June 1			
Shallots	do	do	Oct. 1				
Sorrel	do	do	Oct. 15	Oct. 1	Sept. 1	Aug. 15	July 15.
Spinach	Nov. 1	Oct. 1	do	do	do	do	Aug. 1.
Spinach, New Zealand			Aug. 1	July 15	July 1	June 15	
Squash:							
Summer	Oct. 1	Sept. 1	Aug. 15	Aug. 1	July 15	July 1	June 15.
Winter			July 15	July 1	June 15	June 15	Do.
Sweetpotato [1] [2]							
Tomato[1]	Oct. 1	Sept. 1	Aug. 15	July 15	July 1	June 15	
Turnip greens	Nov. 15	Nov. 1	Oct. 15	Oct. 1	Sept. 1	Aug. 1	July 15.
Turnips	do	do	do	Sept. 1	Aug. 1	July 15	July 1.
Watermelon[2]							

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[1] Plants.

[2] Spring planting only.

Table 3 gives in general the proper depth of planting for the various vegetable seeds as well as the quantity of seeds or number of plants required for 100 feet of row and the distance apart that plants should be spaced. Special planting suggestions will be found under the discussion of cultural hints for the various garden crops.

TABLE 3.—*Quantity of seeds and number of plants required for 100 feet of row, depths of planting, and distances apart for rows and plants*

Crop	Required for 100 feet of row		Depth for planting seed	Distance apart		
				Rows		Plants in the row
	Seed	Plants		Horse cultivation	Hand cultivation	
			Inches	*Feet*		
Asparagus	1 ounce	75	1-1½	4-5	1½ to 2 feet	18 inches.
Beans:						
Lima, bush	1 pint		1-1½	2½-3	2 feet	3 to 4 inches.
Lima, pole	do		1-1½	3-4	3 feet	3 to 4 feet.
Snap, bush	do		1-1½	2½-3	2 feet	3 to 4 inches.
Snap, pole	½ pint		1-1½	3-4	do	3 feet.
Beet	2 ounces		1	2-2½	14 to 16 inches	2 to 3 inches.
Broccoli:						
Heading	1 packet	50-75	½	2½-3	2 to 2½ feet	14 to 24 inches.
Sprouting	do	50-75	½	2½-3	do	Do.
Brussels sprouts	do	50-75	½	2½-3	do	Do.
Cabbage	do	50-75	½	2½-3	do	Do.
Cabbage, Chinese	do		½	2-2½	18 to 24 inches	8 to 12 inches.
Cardoon	do	35	½	3	3 feet	3 feet.
Carrot	do		½	2-2½	14 to 16 inches	2 to 3 inches.
Cauliflower	do	50-75	½	2½-3	2 to 2½ feet	14 to 24 inches.
Celeriac	do	200-250	⅛	2½-3	18 to 24 inches	4 to 6 inches.
Celery	do	200-250	⅛	2½-3	do	Do.
Chard	2 ounces		1	2-2½	do	6 inches.
Chervil	1 packet		½	2-2½	14 to 16 inches	2 to 3 inches.
Chicory, witloof	do		½	2-2½	18 to 24 inches	6 to 8 inches.
Chives	do		½	2½-3	14 to 16 inches	In clusters.
Collards	do		½	3-3½	18 to 24 inches	18 to 24 inches.
Corn salad	do		½	2½-3	14 to 16 inches	1 foot.
Corn, sweet	¼ pint		2	3-3½	2 to 3 feet	Drills, 14 to 16 inches; hills, 2½ to 3 feet.
Cress:						
Upland	1 packet		⅛-¼	2-2½	14 to 16 inches	2 to 3 inches.
Water	do		⅛-¼	2-2½	18 to 24 inches	4 to 6 inches.
Cucumber	do		1	6-7	6 to 7 feet	Drills, 3 feet; hills, 6 feet.
Dandelion	do		½	2½-3	14 to 16 inches	8 to 12 inches.
Dasheen	½ peck	50	2-3	3½-4	3½ to 4 feet	2 feet.
Eggplant	1 packet	50	½	3	2 to 2½ feet	3 feet.
Endive	do		½	2½-3	18 to 24 inches	12 inches.
Florence fennel	do		½	2½-3	do	4 to 6 inches.
Garlic	1 pound		1-2	2½-3	14 to 16 inches	2 to 3 inches.
Horseradish	Cuttings	50-75	2	3-4	2 to 2½ feet	18 to 24 inches.
Jerusalem artichoke	1 to 2 quarts	25-35	2-3	3-4	2 to 3 feet	2 to 3 feet.
Kale	1 packet		½	2½-3	18 to 24 inches	12 to 15 inches.
Kohlrabi	do		½	2½-3	14 to 16 inches	5 to 6 inches.
Leek	do		½-1	2½-3	do	2 to 3 inches.
Lettuce	do	100	½	2½-3	do	15 inches.
Martynia	do		1	3-4	2½ to 3 feet	2 feet.
Muskmelon	do		1	6-7	6 to 7 feet	Hills, 6 feet.
Mustard	do		½	2½-3	14 to 16 inches	12 inches.
Okra	2 ounces		1-1½	3-3½	3 to 3½ feet	2 feet.
Onion:						
Plants		400	1-2	2-2½	14 to 16 inches	2 to 3 inches.
Seed	1 packet		½-1	2-2½	do	Do.
Sets	1 quart		1-2	2-2½	do	Do.
Parsley	1 packet		⅛	2-2½	do	4 to 6 inches.
Parsley, turnip-rooted.	do		⅛-¼	2-2½	do	2 to 3 inches.
Parsnip	do		½	2-2½	18 to 24 inches	Do.
Peas	1 pint		2-3	2-4	1½ to 3 feet	1 inch.
Peppers	1 packet	50-70	½	3-4	2 to 3 feet	18 to 24 inches.
Physalis	do		½	2-2½	1½ to 2 feet	12 to 18 inches.
Poke	do	25-40	½-1	3-3½	3 to 3½ feet	3 feet.
Potato	5 to 6 pounds		4	2½-3	2 to 2½ feet	10 to 18 inches.
Pumpkin	1 ounce		1-2	5-8	5 to 8 feet	3 to 4 feet.

TABLE 3.—*Quantity of seeds and number of plants required for 100 feet of row, depths of planting, and distances apart for rows and plants*—Continued

Crop	Required for 100 feet of row		Depth for planting seed	Distance apart		
	Seed	Plants		Rows		Plants in the row
				Horse cultivation	Hand cultivation	
			Inches	*Feet*		
Radish	1 ounce		½	2 -2½	14 to 16 inches	1 inch.
Rhubarb		25- 35		3 -4	3 to 4 feet	3 to 4 feet.
Salsify	1 ounce		½	2 -2½	18 to 24 inches	2 to 3 inches.
Shallots	1 pound (cloves).		1 -2	2 -2½	14 to 16 inches	Do.
Sorrel	1 packet		½	2 -2½	18 to 24 inches	5 to 8 inches.
Spinach	1 ounce		½	2 -2½	14 to 16 inches	3 to 4 inches.
Spinach, New Zealand.	do		1 -1½	3 -3½	3 feet	18 inches.
Squash:						
Bush	½ ounce		1 -2	4 -5	4 to 5 feet	Drills, 15 to 18 inches; hills, 4 feet.
Vine	1 ounce		1 -2	8 -12	8 to 12 feet	Drills, 2 to 3 feet; hills, 4 feet.
Sweetpotato	5 pounds	[1] 75	2 -3	3 -3½	3 to 3½ feet	12 to 14 inches
Tomato	1 packet	35- 50	½	3 -4	2 to 3 feet	1½ to 3 feet.
Turnip greens	do		¼- ½	2 -2½	14 to 16 inches	2 to 3 inches.
Turnips and rutabagas.	½ ounce		¼- ½	2 -2½	do	Do.
Watermelon	1 ounce		1 -2	8 -10	8 to 10 feet	Drills, 2 to 3 feet; hills, 8 feet.

[1] Slips.

SUCCESSION OF CROPS

All garden space should be kept fully occupied throughout the growing season. In the South this means the greater part of the year; in fact, throughout the South Atlantic and Gulf coast regions it is possible to have certain vegetables growing in the garden every month of the year.

In arranging the garden all early maturing crops may properly be grouped so that after their removal the ground will be available as a unit for planting later crops. As soon as one crop is removed another should take its place. It is not desirable, however, to follow a crop with another of its kind, but with some unrelated crop. For example, early peas or beans can very properly be followed by late cabbage, celery, carrots, or beets; early corn or potatoes can be followed by fall turnips or spinach. It is not always necessary to wait until the early crop is entirely removed, but a later crop may be planted between the rows of the early crop; for example, sweet corn may be planted between the rows of early potatoes. Late cabbage is frequently planted between potato rows. Crops that are attacked by the same diseases should not follow each other.

In the extreme North, where the season is relatively short, there is very little opportunity for succession cropping; therefore plenty of land should be provided to accommodate the desired range of crops.

THE LATE SUMMER AND FALL GARDEN

Farmers the country over would be justified in paying more attention to their late summer and fall gardens. Second and third plantings of crops adapted to growing late in the season not only provide a supply of fresh vegetables for the latter part of the season but give better products for canning and storing. This is particularly true of beans, beets, carrots, and celery. Late-grown beans are especially suitable for canning, while the root crops and celery when matured late in the season are crisp and tender and of better quality for having escaped the summer's heat. In parts of the South the autumn garden is really of as great importance as the early one.

CULTIVATION

Frequent shallow cultivation should be given most garden crops, mainly to keep the garden free from weeds and the surface soil loose and mellow. Weeds draw heavily on the moisture supply and the plant food of the soil; therefore the best time to destroy weeds is just after they start. If the crops are cultivated once a week, especially during the early part of the season, weeds will be controlled, and the crops will get the benefit of the moisture and soil fertility. Under no circumstances should the land be cultivated when wet, but in sections having natural rainfall the garden should be gone over with the cultivator as soon as it is dry enough after a rain to break the crust and thus prevent the baking of the surface soil. If the work is done properly and at regular intervals there will be little difficulty in controlling weeds and keeping the garden crops growing.

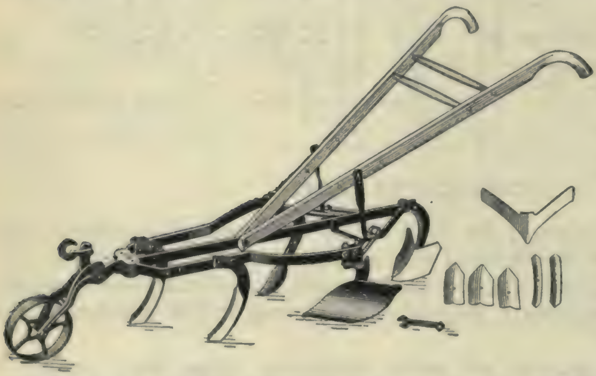

FIGURE 10.—A five-shovel cultivator with attachments, adapted for garden cultivation.

A one-horse, five-shovel cultivator with various attachments, of the type shown in figure 10, is suited for garden cultivation. In all cases the cultivator should be fitted with a lever or some device to regulate its width. Cultivators that stir the soil deeply should not, under most circumstances, be used in the garden, except where some crops, such as potatoes, require the soil to be worked into a ridge about the plants. A sweep is well adapted for cultivating in the middles between the rows. The larger crops in the garden should be cultivated with horse-drawn tools and with a minimum of hand labor. The smaller crops, such as carrots, beets, and lettuce, if planted in rows too close for horse cultivation, may be worked with a hand cultivator of the type shown in figure 11. This implement is fitted with a variety of attachments, enabling the gardener to do many kinds of work.

Hand tools needed in the garden are mainly a hoe, a steel rake, a spade or a spading fork, a planting trowel, a watering can, and a garden line for laying off the rows. It is not necessary to have a large investment in tools. Generally the implements used for other purposes on the farm are adaptable for work in the garden.

IRRIGATION

Throughout that portion of the country where rains occur during the growing season it should not be necessary to irrigate in order to produce the ordinary garden crops. In arid regions where irrigation must be depended upon for the production of crops, the system best adapted for use in that particular locality should be employed in the garden. Wherever irrigation is practiced the water should not be applied until needed, and then the soil should be thoroughly soaked. After irrigation the land should be cultivated as soon as the surface becomes sufficiently dry, and no more water should be applied until the plants begin to show the need of additional moisture. Constant or excessive watering is very detrimental in every case. Apply the water at any time of the day that is most convenient and when the plants require it.

Overhead or sprinkler irrigation is now used extensively in commercial market gardens, especially in sections where the natural rainfall is insufficient at certain periods of the growing season. This system is also suited for use in the home garden if there is an adequate supply of water under pressure. Manufacturers of overhead or sprinkler equipment provide temporary lines of sprinkler pipe which are connected by unions and may be put together or taken apart very quickly. A hose connects the pipe with the water system. These pipes may be supported on stakes, on blocks of wood, or on crates or boxes placed in a row through the garden.[4]

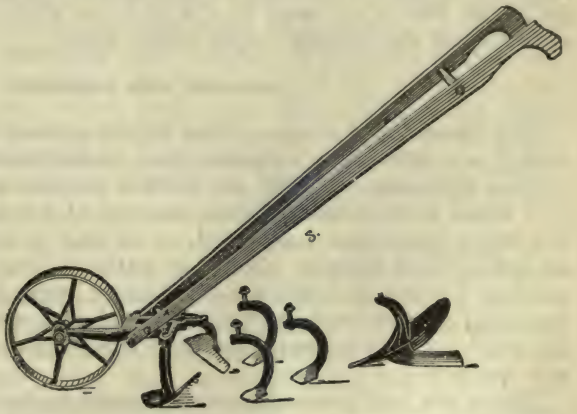

FIGURE 11.—A small hand cultivator, a desirable addition to the garden equipment.

PAPER MULCH

Gardening under paper, or the use of paper as a mulch, has been advocated as a means of eliminating cultivation, controlling weeds, increasing yields, conserving moisture, and raising the temperature of the soil. Under many conditions the use of paper mulch has proved to be advantageous and largely increased yields have been obtained. In some instances the advantages have not justified the expense and labor involved in applying the paper. For the home gardener, however, the chief interest in mulch paper lies in the fact that it reduces the necessity for cultivation during hot weather. The use of paper will control weeds, although a certain amount of hand weeding may be needed around individual plants or between the strips of paper. Paper mulch has hastened the maturity and increased the yields of certain garden crops, particularly those requiring a long season, such as sweetpotatoes, peppers, eggplant, and tomatoes, especially in the more northern States.

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[4] For further information on overhead irrigation, see Farmers' Bulletin 1529, Spray Irrigation in the Eastern States.

Paper mulch as used in home gardens has given most general satisfaction when laid in strips held with a continuous ridge of soil over the depressed edges. Following the laying of the paper over the moist garden soil, the transplants such as tomatoes, cauliflower, and peppers are set at the desired intervals through openings made in the paper with a sharp stick or dibble. Crops such as potatoes, corn, beans, and melons may be seeded through similar openings. The use of mulch paper with small-seeded drill crops requires special methods which vary with the conditions.

While the heavier (type B) mulch papers have proved most suitable for garden use, the lighter (type A) papers have sometimes proved serviceable, particularly on light soils or in regions of reduced rainfall. The cost of the heavier paper required for a plot 50 by 50 feet when used in the manner above described is about $7 and that of the lighter paper about $3.50.

INSECTS AND DISEASES

The insects and diseases that infest garden crops are so numerous that it would be impracticable even to mention them all in a bulletin of this character. There are certain control measures, however, that will often accomplish a great amount of good. In the autumn after the crops have been harvested, or as fast as any crop is disposed of, all refuse that remains should be gathered and burned. Some of the garden insects and disease-producing organisms winter in the remains of garden crops and in the trash and weeds around the garden. By burning such material many of these insects and disease organisms are destroyed.

There are two main classes of insects to be dealt with. The chewing or biting insects may for the most part be controlled by the use of stomach poisons, such as lead arsenate or paris green, or by hand collection or other special methods. The sucking insects, especially the plant lice, must be controlled by contact poisons, such as nicotine or pyrethrum.

For the diseases of vegetables, numerous methods of control are available. Sometimes a single method is effective, but more often several measures must be combined to secure the best results. An illustration of the former is the use of varieties resistant to disease. An example of the latter is the combination of rotation of crops, seed treatment, and spraying for the control of anthracnose of cucurbits.

Among the most important disease-control measures are crop rotation, soil treatment, the use of disease-free seed and plants, seed treatment with fungicides, the use of disease-resistant varieties, spraying and dusting with fungicides, and the eradication of wild host plants on which certain diseases overwinter.[5]

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[5] For details of these control methods see Farmers' Bulletin 1371, Diseases and Insects of Garden Vegetables, and Yearbook Separate 929, Diseases and Pests of Fruits and Vegetables. The latter is out of print, but may be consulted in libraries.

CANNING AND STORING VEGETABLES AT HOME

In sections of the country where a constant supply of fresh vegetables cannot be obtained from the garden throughout the year, it is important that the season for their use be extended by means of canning and storage. Nonacid vegetables, such as asparagus, beans, corn, peas, beets, and spinach, must be canned under steam pressure rather than by the hot-water process. Tomatoes, being an acid vegetable, may be safely canned by the boiling-water process. Pressure cookers are now standard equipment in many homes and may be used for the canning of vegetables. It is important, however, that the pressure cooker be equipped with thermometer, pressure gage, and safety valve for proper control. There are also on the market satisfactory hand machines for sealing tin cans, making it possible to apply factory methods in the canning of vegetables in the home.[6]

The home storage of vegetables is, perhaps, of greater importance than canning because of its adaptation to all that portion of the country where freezing temperatures prevail during the winter months. There are at least 10 important vegetables that can be stored for winter use, the success attending their storage depending largely on the way the work is handled. Certain vegetables, like cabbage, turnips, beets, carrots, and celery, may be stored in pits in the open ground; potatoes, sweetpotatoes, and onions are stored to best advantage in cellars or specially designed storage houses. Temperature, moisture control, and ventilation are the main points involved in the successful home storage of vegetables.[7]

The root crops, including beets, carrots, winter radishes, and turnips, also such crops as collards, kale, and spinach, may remain where they are grown throughout the late fall and early winter in nearly all parts of the South. These crops, however, will start a new growth as soon as the weather begins to get warm in the late winter and will produce seedstalks, after which they are unfit for the table. In sections of the South where temperature conditions make it impossible to store vegetables for off-season use, canning and drying should be substituted.

CULTURE OF SPECIFIC GARDEN CROPS

PERENNIAL VEGETABLES

Perennial vegetables, especially asparagus, horseradish, and rhubarb, are among the most valuable garden products. They occupy comparatively little space and when once planted continue to yield for a number of years. It is usually best to locate these perennials along one side of the garden where they do not interfere with work on the annual plants. Unfortunately, these three important perennials are not adapted to culture in all sections and cannot be grown in parts of the lower South. Because of their desirability, the perennials should be included in every garden where space and adaptability permit their culture.

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[6] Farmers' Bulletin 1471, Canning Fruits and Vegetables at Home, gives information on proper methods of canning.

[7] Farmers' Bulletin 879, Home Storage of Vegetables, gives information relative to storage structures and methods of caring for vegetables in storage.

ASPARAGUS

Asparagus is wholesome and in many sections is among the earliest of the spring vegetables. An area about 20 feet square, or a row 50 to 75 feet long, will supply plenty of asparagus for a family of five or six persons, provided the soil is well enriched and the plants are given good attention.

Asparagus does best in locations having winters sufficiently cold to freeze the ground to a depth of at least a few inches, but it is not adapted to all portions of the lower South. In many southern locations the plants make a weak growth, producing small shoots. Elevation has some effect, but in general the latitude of south-central Georgia is about the southern limit of profitable culture.

The crop can be grown on almost any well-drained, fertile soil, and there is little possibility of having the land too rich, especially through the use of manure. As an asparagus planting will last for many years, it should be located where it will interfere as little as possible with other gardening operations.

Since asparagus roots go deep for their supply of moisture and plant food, the land should be loosened far down either by subsoil plowing or deep spading before planting. It is a good plan to throw the topsoil aside and spade manure, leaf mold, rotted leaves, or peat into the subsoil to a depth of 14 to 16 inches. From 5 to 10 pounds of a complete fertilizer should also be mixed into each 75-foot row or 20-foot bed.

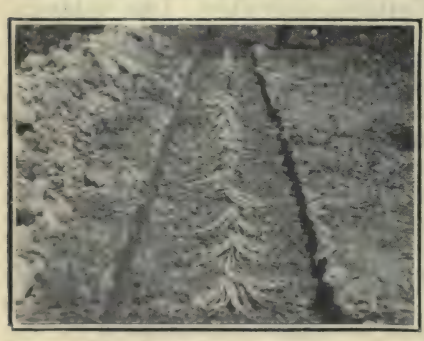

FIGURE 12.—Asparagus crowns or plants being set in a trench.

When ready for planting, the bottom of the trench should be about 6 inches below the natural level of the soil (fig. 12). After the crowns are set and covered to a depth of an inch or two, the soil should be gradually worked into the trench around the plants during the first season. When set in beds, asparagus plants should be at least 1½ feet apart each way; when set in rows they should be about 18 inches apart, with the rows from 4 to 5 feet apart.

Asparagus plants or crowns are grown from seed. The use of 1-year-old plants only is recommended. These should have a root spread of at least 15 inches, and larger ones are better. The home gardener will usually find it best to purchase his plants from some grower who has a good strain of a recognized variety. Mary Washington is a good variety that has the added merit of being rust resistant. In procuring asparagus crowns it is always well to be sure that they have not been allowed to dry out.

Clean cultivation encourages vigorous growth. Weeds and grass are usually responsible for unsatisfactory results with asparagus, and it behooves the gardener to keep his asparagus clean from the start. In the large farm garden with long rows most of the work can be done with a horse-drawn cultivator, but in the small garden, where the rows are short or the asparagus is planted in beds, handwork must be resorted to.

White asparagus is produced by mounding the rows or hills with earth to keep light away from the young spears. Hilling is begun during the early spring and continued throughout the cutting season as needed, but in most cases, especially on light-textured soils, the initial hilling should be sufficient. On heavier soils the earth must be added more slowly. At the end of the cutting season these ridges are leveled down.

It is well to make an annual application of manure to asparagus. A liberal dressing of a high-grade complete fertilizer, 6 to 8 pounds to a 75-foot row, once each year, is also necessary. Both manure and fertilizer should be used at the end of the cutting season.

No shoots should be removed the year the plants are set in the permanent bed, and the period of cutting should be short the year after setting. During the cutting season in subsequent years all shoots should be removed. About July 1 to 10 cutting should cease and the tops should be allowed to grow. In the autumn, when dead, they can be removed and burned.

Asparagus rust and asparagus beetles are the chief enemies of asparagus. Directions for their control are given in Farmers' Bulletin 1371, Diseases and Insects of Garden Vegetables.[8]

HORSERADISH

Horseradish is adapted for growing in the north-temperate regions of the United States, but it is not suited for planting in the South except possibly in the high altitudes. Grated horseradish is a very desirable condiment, always best when fresh. A few plants in an out-of-the-way place in the garden, such as a corner, will supply enough for the family.

Any good soil, except possibly the lightest sands and heaviest clays, will grow horseradish, but it does best on a deep, rich, moist loam that is well supplied with organic matter. A shallow soil should be avoided, as it produces rough, prongy roots. Manure should be mixed with the soil a few months before the plants or cuttings are set. Some fertilizer may be used at the time of planting and more during each subsequent season. A top-dressing of manure each spring is advisable, but a good, deep soil in an old garden will usually grow good horseradish without heavy manuring or fertilization.

Horseradish seldom forms seed; it is propagated either by using crowns or by root cuttings. In propagating by crowns, a portion of an old plant consisting of a piece of root and crown buds is merely lifted and placed in a new location. Root cuttings are pieces of older roots 6 to 8 inches long and of the thickness of a lead pencil. These may be saved when preparing the larger roots for grating, or they may be purchased from seedmen. A trench 4 or 5 inches deep is opened with a hoe and the root cuttings placed at an angle with their tops near the surface of the ground. Each cutting will sprout in several places, and after they are well established the soil should be carefully removed by hand from around the cuttings. All but one good cluster of leaves near the top of each cutting should be removed. The soil should then be replaced. These plants usually make good roots the first year. As a rule the plants in the home garden are allowed to grow from year to year, and portions of the roots are removed as needed. Pieces of roots and crowns remaining in the soil are usually sufficient to reestablish the plants.

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[8] Additional information on asparagus culture is given in Farmers' Bulletins 1242, Permanent Fruit and Vegetable Gardens, and 1646, Asparagus Culture.

Horseradish is prepared by cleaning and grating the roots directly into white wine vinegar or distilled vinegar of 4½ to 5 percent acid content. Bottled and sealed immediately, it keeps for a few weeks. Dried, ground, and bottled, it keeps for some time, but this product is not as good as when the horseradish is grated fresh and mixed with vinegar. Cider vinegar should not be used, as it causes the horseradish to turn dark.

POKE

Poke, also known as scoke and garget, is grown and used to some extent as an early spring vegetable. The plant is commonly found growing wild along fences and around farmyards and in other places where rich, moist soil is to be found. Poke is a common carrier of the mosaic disease, and it should not be grown with crops susceptible to this disease.

Poke is propagated by taking portions from the crowns of the plant and setting these in a new location. The culture of poke is similar to that of asparagus. Poke must have a fertile soil; but given that, no additional fertilization is needed. Like horseradish, poke may be planted along one side of the garden where it can remain for years. New plants soon arise from the old, and a few crowns spaced 2 to 3 feet apart soon occupy as much space as the average gardener cares to give it.

The young shoots that come up first in spring are used for food. They are taken just as they come through the loose earth and while they are still white and tender. Mulching with leaves or straw will aid in keeping the shoots white and tender. They are cut in the same way as asparagus, but care should be taken to avoid taking any portion of the root, as it contains a poisonous alkaloid. Poke is cooked, seasoned, and eaten in the same way as asparagus or as greens.

RHUBARB

Rhubarb thrives best in regions having cool moist summers and winters sufficiently cold to freeze the ground to a depth of several inches. It is not adapted to most portions of the South, but in certain regions of higher elevation it does fairly well. Rhubarb, like asparagus, is a perennial, and a few hills along the garden fence will supply all that a family can use. In sections where it thrives, rhubarb should be in the garden, for it comes early in the spring and has fine dietetic qualities.

Any deep, well-drained, fertile soil is suitable for rhubarb. It should be spaded or plowed to a depth of 12 to 16 inches, and rotted manure, leaf mold, decayed hardwood leaves, sods, or some other form of organic matter should be mixed with it. The methods of soil preparation suggested for asparagus are suitable for rhubarb; but as rhubarb is planted in hills 3 to 4 feet apart, it is usually sufficient to prepare each hill separately.

Rhubarb plants may be started from seed and transplanted, but seedlings vary from the parent plant. The usual method of starting the plants is to obtain pieces of crowns from established hills and set them in prepared hills. Cultivation is confined to the control of weeds. The planting should be top-dressed with a heavy application of manure in either early spring or late fall. Fresh horse manure applied over the hills during early spring greatly hastens growth or "forces" the plant.

If plenty of manure can be obtained, rhubarb needs little if any commercial fertilizer. However, a pound of complete commercial fertilizer high in nitrogen applied around each hill every year insures an abundant supply of plant food. In the absence of manure the plants can be mulched with green grass or weeds, and commercial fertilizer may be applied more liberally, but some manure is very desirable.

Seedstalks should be removed as soon as they form, because seed bearing greatly weakens the plant. No leaf stems should be harvested before the second year and but few until the third. Moreover, the harvest season must be largely confined to early spring, as the plants should be allowed to grow undisturbed during summer. The hills should be divided and reset every 7 or 8 years. If not, they become too thick and produce only slender stems.

Only the leaf stem of the rhubarb is used as a vegetable. The leaves contain injurious materials such as oxalic acid, and in no case should they be used for food. They make excellent covers to protect tomato, cabbage, and other plants for the first day or two after setting.

GREENS

Greens may be defined as the leaves and stems of young plants, such as spinach, which in their green state are boiled for food. The classification of greens in this bulletin is an arrangement of convenience, for plants such as collards are really greens also. The plants treated here as greens are hardy vegetables, most of which are adapted to fall sowing and winter culture over the entire South and the more temperate portions of the North. Their culture may be extended over a wider area of the North by growing them with some protection, such as mulching or frames. Greens are especially valuable vegetables in that they are high in minerals and vitamins.

CARDOON

Cardoon is a large thistlelike plant (fig. 13) which is grown for its fleshy leaf stems. In the North the seeds are sown in early spring in a hotbed or coldframe and the plants transplanted later to the open ground. In the South the seed may be sown in the rows where the plants are to be grown. The plants should be placed about 3 feet apart each way in rich soil with plenty of moisture, but they do not thrive on poorly drained land. Toward autumn the leaves are drawn together and blanched by wrapping with paper, by slipping a draintile over each plant, or by other methods of excluding light. If intended for winter use, the leaves are not blanched in the garden, but the plants are lifted with considerable earth adhering to the roots and stored in a cellar or pit to blanch.

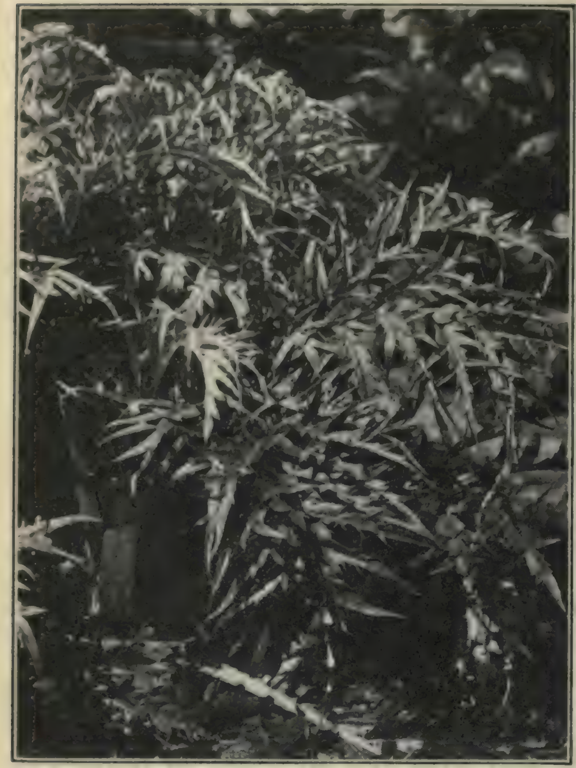

FIGURE 13.—Cardoon, a large thistlelike plant which is bleached for use.

The leafstalks are boiled and served as a green or used in the making of soups and stews. Cardoon is usually somewhat bitter, and it has only a limited field of usefulness as a home garden crop.

CHARD

Chard, or Swiss chard, is a type of beet that has been developed for its tops instead of its roots. The leaves are cooked and used as greens in very much the same way as spinach. The thickened leaf stems are sometimes cooked and used in much the same way as asparagus. One of the advantages of this vegetable is that crop after crop of the outer leaves may be harvested without injuring the plant. Only one planting is necessary, and a row 30 to 40 feet long will supply a family for the entire summer. Figure 14 shows the habit of growth of Swiss chard. Its culture is practically the same as that of beets, but the plants grow larger and should be thinned to at least 6 inches apart in the row. In common with beets, chard demands a rich mellow soil; and as it is sensitive to soil acidity, it is usually wise to use a little lime on the land before planting it. The seed clusters each contain several seeds, and fairly wide spacing will facilitate thinning.

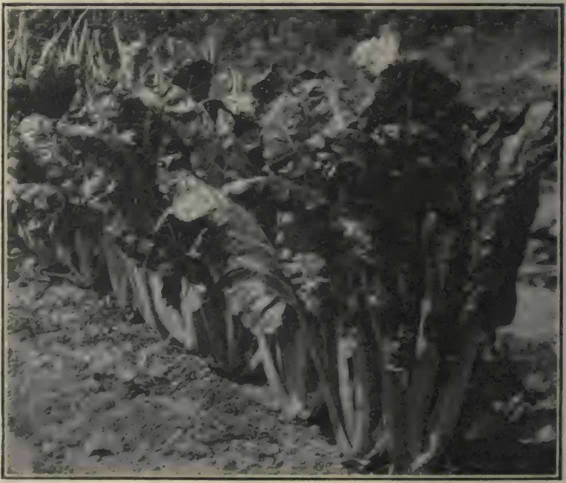

FIGURE 14.—Swiss chard, excellent hot-weather greens.

DANDELION

FIGURE 15.—Dandelion, which under favorable conditions gives a heavy yield of greens.

The dandelion is hardy and adapted to much the same conditions as kale and mustard. It will grow on almost any garden soil. In the North the seeds are usually sown during early spring in rows about 18 inches apart and covered to a depth of about half an inch. The plants should be thinned to 8 to 12 inches apart in the rows and cultivated throughout the summer (fig. 15). In the colder parts of the country it may be desirable to mulch slightly during the winter, using leaves, straw, or strawy manure. Early the following spring the plants will be ready for use as greens. In the South, the seed may be sown during the autumn, and the plants will be ready for use in the spring. Dandelion is greatly improved if blanched by being covered with paper or by having two boards set in the form of a letter A over the row. The blanching not only makes the leaves more tender but destroys part of the bitter taste.

KALE

Kale, or borecole, is hardy like spinach and lives over winter in latitudes as far north as northern Maryland and southern Pennsylvania and in other locations where similar winter conditions prevail. It is also resistant to heat and may be grown in summer, but its real merit is as cool-weather greens.

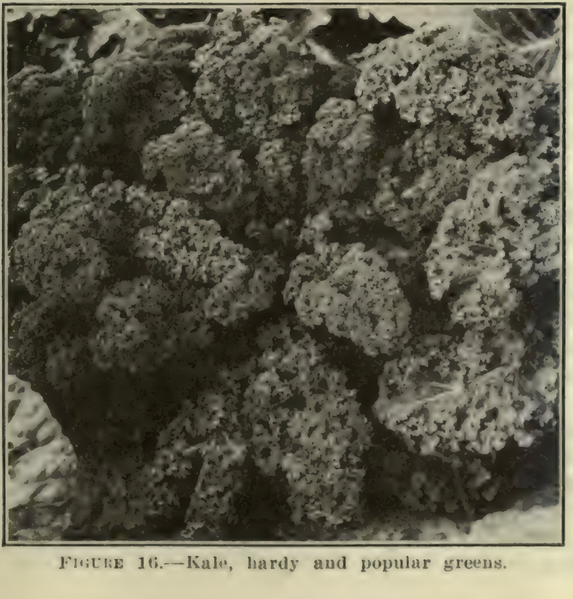

FIGURE 16.—Kale, hardy and popular greens.

Kale is a member of the cabbage family, and the best garden varieties are low-growing, spreading plants with thick, more or less crinkled leaves (fig. 16). Scotch Curled and Siberian are two of the best-known garden varieties.

In the home garden in the North kale may be seeded almost any time from early spring until a few weeks before hard frost. In northern regions where it lives over winter the last sowing should be about 6 weeks before frost in order that the plants may become well established. In the South it may be seeded almost any time, but it has little to commend it during midsummer and is seldom sown to mature during this season. No other plant is so well adapted to fall sowing throughout a wide area both North and South or in regions characterized by winters of moderate severity. It may well follow green beans, potatoes, peas, or some other vegetable that has occupied the ground during the early season.

Almost any garden soil will grow good kale. When it follows in the same season another crop that has been fertilized, kale should need little if any additional plant food. It may be broadcast like turnips, particularly when seeded during the autumn; but for spring sowings, made at a time when weeds are troublesome, row seeding is advised. The seed should be covered lightly, usually by being raked in with a garden rake. Cultivation is limited to that necessary for the control of weeds.

Kale may be harvested either by cutting the entire plant or by taking the larger leaves while young. Old kale is liable to be tough and stringy. The culture of kale is easy, and the gardener is advised to pay more attention to this excellent green.

MUSTARD

Almost any good soil will produce a crop of mustard. The basal leaves are used for greens; and as the plants require but a short time to reach the proper stage for use, frequent sowings should be made. Sow the seeds thickly in drills as early as possible in the spring, or for late use sow in September or October. The forms of Chinese or Japanese mustard, the leaves of which are often curled and frilled, are generally used. Mustard greens are cooked like spinach.

SPINACH

Spinach is by far the most popular of the greens. It is a reasonably hardy cool-weather plant that withstands winter conditions throughout most portions of the South. In colder portions of the Southern States it may need some protection during the winter, for, like cabbage and other hardy crops, it is sometimes severely injured or even killed by low temperatures. In most portions of the North spinach is primarily an early spring and late fall crop, but in certain locations where summer temperatures are mild it may be grown continuously from early spring until late fall. It should be emphasized that the summer and winter culture of spinach is possible only where moderate temperatures prevail.

Spinach will grow on almost any type of well-drained, fertile soil where sufficient moisture is available. If possible a rich friable loam with an abundance of organic matter should be used. The home gardener will find spinach adapted to his land whether it be a heavy clay or a peat so long as it is well drained and rich. Spinach is very sensitive to acid soil; if any doubt exists regarding the need of the soil for lime, it may be wise to apply a few pounds to the portion of the garden devoted to spinach, irrespective of the treatment given the remainder of the area.

The general application of both manure and fertilizer to the garden has been advised in an earlier portion of this bulletin. Spinach will profitably use additional supplies of both. A pound of rotted manure to each square foot and 3 to 4 pounds of commercial fertilizer to each 100 square feet of land is suggested as suitable rates of application for spinach in the home garden. Both manure and fertilizer should be applied broadcast and raked in before the spinach is sown.

In the North spinach may be sown as early in the spring as it is possible to prepare the ground. Two or three successive plantings at intervals of one week should be made until the approach of hot weather, or about June 1, but these later plantings cannot be expected to yield as heavily as the earlier ones. Plantings may again be started during the late summer and continue until about 6 weeks before frost. In sections having cool summers, plantings may be made in succession throughout the growing season or until a few weeks before frost. In the South the time of planting depends upon locality and season. In general it extends from early fall to late spring, but it is useless to attempt spinach culture in midsummer. The zone maps and tables give the approximate dates for sowing spinach in various parts of the country.

The variety Nobel, also known as Giant Thick Leaf, is recommended, as it grows quickly, is very productive, the smooth leaves are easily cleaned, and it stands for a long time before going to seed. Virginia Savoy and Old Dominion are valuable varieties for fall planting as they are resistant to "yellows" or "blight" and very hardy. They are not suitable for the spring crop as they produce seedstalks quite easily. Great care should be taken to obtain seed that is fresh and of good quality. For horse cultivation, the rows should not be less than 24 inches apart, and when land is plentiful they may be 30 inches apart. For garden tractor, wheel hoe, or hand work, the rows should be 12 to 18 inches apart. Spinach may be drilled by hand in furrows about 1 inch deep made with a hoe or other device and covered with fine earth not more than one-half inch deep, or it may be drilled with a seed drill, which distributes the seed more evenly than is ordinarily possible by hand. The use of the drill is advised. The plants should be thinned to 3 or 4 inches apart before they crowd in the row.

NEW ZEALAND SPINACH

New Zealand spinach is not related to common spinach. It is a large plant with thickish leaves and stems and grows with a branching, spreading habit to a height of 2 or more feet. It thrives in hot weather and is grown as a substitute at seasons when the ordinary spinach cannot withstand the heat. New Zealand spinach thrives on soils suitable for common spinach. Because of the larger size of these plants they must be given more room. The rows should be at least 3 feet apart, with the plants about 2 feet apart in the rows. The seeds may be sown 1 to 1½ inches deep as soon as danger of frost is past. As some difficulty may be experienced in getting the seeds to germinate promptly, they should be soaked for one or two hours in water at 120° F. before being planted. Successive harvests of the tips may be made from a single planting, since new leaves and branches are readily produced. Care must be taken not to remove too large a portion of the plant at one time lest later harvests suffer. New Zealand spinach is cooked in the same way as common spinach.

SORREL

Sorrel is not well known to the majority of gardeners; yet it is highly prized by many, especially for cooking with spinach to give it added flavor. It is a perennial plant that is usually started from seeds. It requires a rich, mellow, well-drained soil. Rows may be of any convenient width, and the plants should be thinned to about 8 inches apart in the rows. If the leaves alone are gathered and the plants are cultivated to prevent the growth of weeds, a planting should last 3 or 4 years. Broad-Leaved French is a well-known variety.

TURNIP GREENS

Varieties of turnips usually grown for the roots are also planted especially for the greens. Shogoin is the most favorable variety for spring greens as it is quite resistant to aphis damage and produces fine quality white roots if allowed to grow. Strains of turnips especially suitable for greens are now available under different names. In most cases turnips are seeded thickly and thinned for use as greens, the rest being left to develop as a root crop. Turnip greens are especially adapted to winter and early spring culture in the South. The cultural methods employed are the same as those described under Turnip and Rutabaga (p. 48).

SALAD CROPS

The group known as salad crops includes vegetables that are usually eaten raw with salt, vinegar, pepper, or salad oils, or with mayonnaise or other dressings. This classification is entirely one of convenience, as other vegetables not included in this group are also used in the same way. Some members of this class are sometimes cooked and used as greens.

Lettuce and celery far outweigh all the other plants of this group in popularity. Practically every garden includes a bed or a few rows of lettuce, and it would be more generally grown if gardeners fully appreciated its possibilities.

CELERY

Like most other vegetables, celery can be grown in home gardens in practically all parts of the country at some time during the year. It is a cool-weather crop and adapted to winter culture in the lower South. In the upper South and in the North it may be grown either as an early spring or as a late fall crop. Farther north in certain favored locations it can be grown throughout the summer.

Rich, moist, but well-drained, deeply prepared, mellow soil is essential for celery. Soil varying from sand to clay loam and to peat may be used as long as these requirements are met. Unless the ground is very fertile, plenty of well-rotted barnyard manure, supplemented by liberal applications of commercial fertilizer, is necessary. For a 100-foot row of celery, four or five wheelbarrow loads of manure and 5 pounds of a high-grade complete fertilizer thoroughly mixed with the soil is none too much. The celery row should be prepared a week or two before the plants are set.

The most common mistake with celery is failure to allow enough time for growing the plants. It requires about 10 weeks to grow good celery plants such as those shown in figure 17. For the early crop in the North, which is set outdoors as soon as frosts are over, or about April 15 in the latitude of Indianapolis, Ind., the seeds must be sown in the hotbed or greenhouse about February 1. For the late crop in the same latitude, which is set about July 1, the plants must be started about April 15. The zone tables and maps indicate the planting dates for the various regions. Celery seed is small and germinates slowly. A good method is to place the seeds in a muslin bag and to soak them overnight, after which they are mixed with dry sand and distributed in shallow trenches in the seed flats or seed bed and covered with leaf mold or similar material to a depth of not more than one-eighth inch. The bed should be kept from drying out by being covered with burlap sacks which are kept moist, or by similar means. Celery plants are very delicate and must be kept free from weeds. They are made more stocky by being transplanted once before they are set in the garden, but this practice retards their growth. When they are to be transplanted before being set in the garden, the rows in the seed box or seedbed may be only a few inches apart; but if they are to remain in the box until transplanted to the garden, the plants should be about 2 inches apart each way. In beds, the rows should be 10 to 12 inches apart, with the seedlings 1 to 1½ inches apart in the row.

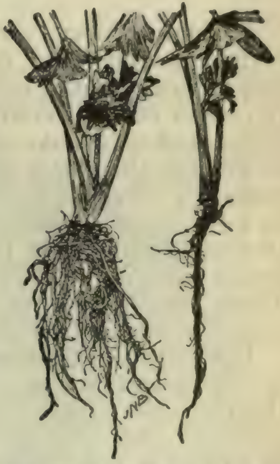

FIGURE 17.—Two celery plants: Left, transplanted once before time for setting in the field; right, not transplanted from original seed bed.

Celery may be set in single or double rows about 4 feet apart or in a bed. In single rows the plants are spaced about 6 inches apart; in double rows the spacing is the same, but two rows are placed side by side about 1 foot apart. In bed culture the plants may be set 1 foot apart each way. Row culture is usually best, especially when the celery is to be banked with earth. Set celery on a cool or cloudy day, if possible; and if the soil is at all dry, set the plants in place, cover the roots lightly, water, and then place more soil around them. If the plants are large, it is best to pinch off the outer leaves 3 or 4 inches from the base before setting. In bright weather it is also well to shade the plants for a day or two after they are set. Small branches bearing green leaves, stuck in the ground, protect the plants from intense sun without excluding air. As soon as the plants attain some size the leaves should be drawn together and the soil gradually worked around the plants to keep them upright. Care must be taken to avoid getting soil into the hearts of the plants. Early celery is blanched with boards, paper, draintiles, or other devices for excluding the light. In addition to these means, late celery may be blanched also by banking with earth or by storing in the dark. Banking celery with soil in warm weather causes it to decay.

Late celery may be kept for early winter use by banking with earth and covering the tops with leaves or straw to keep them from freezing, or it may be dug and stored in a cellar or a coldframe, with the roots well embedded in moist soil. While in storage it must be kept as cool as possible without freezing.

For the home garden either the Golden Self Blanching or the Golden Plume are adapted for the early crop to be used during the late summer, the fall, and the early part of the winter. For storage and for use after the holiday season it is desirable to plant some such variety as Easy Bleaching Green, Utah, or the old variety known as Giant Pascal. Crispheart, Emperor, and Winter Queen are excellent varieties for late-fall and winter use.

WITLOOF CHICORY

Witloof chicory, sometimes called French endive, is grown for both roots and tops. It is a hardy plant that is not especially sensitive to heat or cold, but it does need a deep, rich, loamy soil without too much organic matter. The tops are harvested while young and boiled and eaten like spinach. It is necessary when boiling chicory to change the water once or twice to remove the bitterness. The roots are lifted in autumn and placed in a box or bed of moist soil in a warm cellar for forcing. They must be covered with a foot or two of manure or a few inches of sand. Under this covering the leaves form in a solid head which is known on the market as witloof. These blanched leaves may be used as a raw salad or cooked and eaten like spinach or chard.

The culture of chicory is simple. The seeds are sown during spring or early summer in drills about 18 inches apart and the plants thinned to 6 or 8 inches apart in the rows. If sown too early the plants shoot to seed and are worthless for forcing. The kind known as witloof is most generally used.

CORN SALAD

Corn salad is also known as lamb's-lettuce and fetticus. The seed is sown during the early spring in drills and the plants cultivated the same as for lettuce or mustard. For an extra-early crop the seed may be planted during the autumn and the plants covered lightly during the winter. In the Southern States the covering is not necessary, and the plants are ready for use during February and March. The leaves are frequently used in their natural green state, but they may be blanched by covering the rows with anything that will exclude the light. Corn salad is used as a salad in place of lettuce, or mixed with lettuce or water cress. Its flavor is very mild, and it is improved by being mixed with some other salad plant. It is also boiled with mustard for greens.

ENDIVE

Endive closely resembles lettuce in its requirements and habits of growth, except that it is not so sensitive to heat. It may be substituted for lettuce when the culture of lettuce is impracticable. In the South it is mainly a winter crop. In the North it is grown during the spring, summer, and autumn and is also forced during the winter. Endive is often known on the markets as escarolle. Broad-Leaved Batavian is a good sort.

The time of seeding is given in tables 1 and 2 and depends upon the location. Sow the seeds thinly; and when the plants are established, thin to the same distance as for lettuce, or about 1 foot apart in the rows. When the plants are large and well-formed, draw the leaves together and tie so the heart will blanch. For winter use the plants should be lifted with a ball of earth, placed in a cellar or coldframe where they will not freeze, and tied and blanched as needed.

Endive is used in the same way as lettuce. Its agreeable flavor makes it a most excellent addition to the list of vegetables. Figure 18 shows the appearance and character of endive.

LETTUCE

Lettuce should be found in every home garden. It is a cool-weather crop, being as sensitive to heat as any vegetable grown. In the South lettuce culture is confined to late fall, winter, and spring. In colder portions of the South lettuce may not live through the winter, especally during seasons of low temperature. In the North lettuce culture is practically limited to the spring and autumn, as both winter and summer are too severe for it. In some favored locations, such as areas of high altitude or in far-northern latitudes, lettuce grows to perfection during the summer. In general, zones A, B, and C shown in figure 6 are adapted to fall, winter, and spring culture, and zones D, E, F, and G to spring and autumn culture. Frequent complaints from gardeners regarding poor results obtained with lettuce have been traced almost invariably to failure to realize its limitations, resulting in planting it at the wrong season.

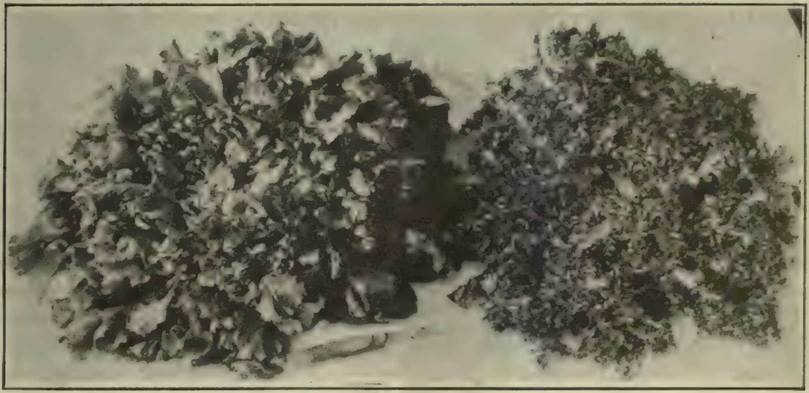

FIGURE 18.—Broad-Leaved Batavian and Moss-Curled varieties of endive. The former is often called escarole.

Any rich soil is adapted to lettuce. The plant is sensitive to lack of lime, and if the soil is strongly acid a few pounds of lime should be applied. A commercial fertilizer with a heavy proportion of phosphorus will also help. Rotted manure may well be applied to ground on which lettuce is to be grown, but the use of fresh, strawy manure should be avoided.

Spring lettuce should be started indoors or in a hotbed and transplanted to the garden when the plants have four or five leaves. Gardeners need not wait for the cessation of light frosts, as lettuce is not usually harmed by a temperature as low as 28° F. if the plants have been properly hardened. About 6 weeks should be allowed for growing the plants. Gardeners in northern Virginia, who set their plants in the open about April 15, must sow the seeds indoors about March 1. When plants cannot be grown indoors or purchased, seeding should be done as early as the ground can be worked. For the fall crop the seed may be sown directly in the row and thinned, as there is no gain in transplanting.

For horse cultivation lettuce plants should be set 12 to 15 inches apart in rows 24 to 30 inches apart, and for hand culture about 12 to 15 inches apart each way. When the seed is sown directly in the row the plants should be thinned to the distances just mentioned. Where gardeners grow leaf lettuce, or desire merely the leaves and not well-developed heads, the spacing in the rows may be much closer. In any case it is usually best to cut the entire plant instead of removing the leaves.

There are many excellent varieties of lettuce, all of which do well in the garden when conditions are right. Of the loose-leaf kinds, Early Curled Simpson and Prize Head are among the best. Grown by the transplanting method described, individual plants of either of these may attain a weight of as much as 2½ pounds. Of the heading sorts, May King, Unrivaled, Big Boston, New York, Iceberg, and Hanson are all excellent. Both New York and Iceberg need more time than May King, Unrivaled, and Big Boston. In regions where warm weather comes early, it is seldom worth while to sow head lettuce seed in the open ground in the spring with the expectation that firm heads will be obtained.

PARSLEY

Parsley is hardy to cold but sensitive to heat. It will thrive under much the same temperature conditions as kale, lettuce, or spinach. If given a little protection it may be carried over winter throughout most of the North, but it cannot withstand extreme heat.

Parsley will thrive on any good soil, but as the plant is delicate during its early stages of growth, the land should be mellow, not subject to baking, and free from clods and stones. In common with most vegetables, parsley needs plenty of soil fertility.

The seeds of parsley are small, and they germinate slowly. Soaking in water overnight will hasten germination. In northern locations it is a good plan to sow the seeds indoors and transplant the plants to the garden, thereby obtaining the crop ahead of hot weather. In the South it is usually possible to sow the seed directly in drills. For the fall crop in the North, row seeding is also practiced. After seeding it is well to lay a board over the row for a few days until the first seedlings begin to appear. After its removal the plants should be watered from day to day to insure germination of as many seeds as possible. Parsley rows should be 14 to 16 inches apart, with the plants 4 to 5 inches apart in the rows.

The leaves of parsley are used for garnishing and for flavoring soups and vegetables. A few feet of row will supply the family, and a few plants transplanted to the coldframe in the autumn will give a supply during early spring.

UPLAND CRESS

Upland cress, sometimes erroneously called peppergrass, is a hardy plant. It may be sown in all the milder portions of the country during autumn. In the colder sections it is sown during early spring as soon as the ground can be worked. The seeds are small and must not be covered deeply. After the plants are well established, thin to 4 to 6 inches apart in the rows. It is a short-season crop that should be planted in quick succession to insure a steady supply. The leaves and young shoots are used as a green salad or cooked like greens.

WATER CRESS

Water cress is one of the few vegetable crops that can be grown in wet surroundings. In the more moderate portions of the North it grows practically the year round, and winter is its best season in the South. It is best and most easily produced in water from springs in limestone regions; the limestone regions of Virginia, Maryland, Kentucky, and the Ozarks give almost ideal conditions. A supply for the family may be grown in a small spring-fed brook or a series of shallow pools where the water is about 1 foot deep. Care must be taken, though, to have a clean supply of water; otherwise the cress is unfit for use.

Water cress is started from seed and from pieces of plant. It is best to prepare the bed, using plenty of rotted manure, and turn the water on after the seeds or cuttings are in place. Early spring is the best time to plant water cress. Often seeds or cuttings may be placed in the rich, moist soil found at the edges of springs or brooks. No special care is required. The plant grows profusely in the wild state. A bed will yield a good crop the first season. Cress is used in salads for its pleasant pungency.

ROOT AND TUBER-ROOT CROPS

Potatoes in the North and sweetpotatoes in the South are found in almost every garden. Other members of this group, especially beets, carrots, and turnips, are of almost the same importance. The vegetables in this classification may be used throughout the growing season and also be kept for winter. Without the supply of root crops from the home garden many families would have a restricted diet. They represent a very large proportion of the total value of home-garden crops.

BEET

The beet is well adapted to all parts of the country. It is not especially sensitive to heat, and it is also resistant to cold; however, it will not withstand severe freezing, and in the lower South, where beets are usually grown the year round, they are sometimes killed by winter freezes. Farther north the winters are too severe, but spring, summer, and autumn culture is practiced. Owing to its wide adaptability and fine qualities, including the presence of vitamins B and C, the beet ranks near the top among home-garden vegetables.

The approximate time for sowing beets in the different parts of the country is shown in table 1. As a rule, beets may be sown in the North as early as the ground can be worked in the spring; in the South they may be planted at almost any time, but midsummer heat and drought may interfere with germination. By covering the seeds with sandy soil, leaf mold, or some other material that will not bake, and by keeping the soil damp until the plants are up, much of this trouble can be avoided. Successive sowings should be made at intervals of about 3 weeks in order to have a continuous supply of young, tender beets throughout the season. Beets are sensitive to the reaction of the soil, and it is usually wise to apply lime if the soil is known to be strongly acid. Good quality depends upon quick development, and the land must be fertile, well drained, and in good physical condition. Well-rotted manure, supplemented by commercial fertilizer having a high proportion of both phosphorus and potash, is recommended, both the manure and fertilizer to be applied broadcast before the seed is planted.

In gardens where cultivation is done by hand the rows may be about 16 inches apart; for horse cultivation they must be wider. Beet seed as purchased consists of small balls, each containing several seeds. These must be spaced thinly to avoid crowding. On most soils the seed should be covered to a depth of about an inch. After the plants are well established they should be thinned to stand 2 to 3 inches apart in the rows.

Early Wonder and Crosby Egyptian are standard varieties of beets suitable for early home-garden culture. Detroit Dark Red is an excellent variety for fall culture for winter use.[9]

CARROT

Since about 1920 the carrot has made a remarkable rise in the esteem of gardeners. It was formerly grown mainly for storage for winter use, but the American housewife has learned to appreciate the worth of young, tender carrots, and they are now planted in succession and grown in much the same way as beets, thereby insuring a continuous supply of tender, succulent roots. From a dietetic standpoint carrots are particularly desirable, especially for children, as they are rich sources of vitamins A, B, and C. Moreover, they contain a yellow coloring matter known as carotin, which is also beneficial.

The carrot is hardy and is fairly resistant to heat. In the South carrots are largely grown during fall, winter, and spring, and gardeners in that part of the country can have a practically continuous supply. In the North the carrot can be grown and used throughout the summer and the surplus stored for winter. The carrot will grow on almost any type of soil as long as it is moist, fertile, loose, and free from clods and stones, but sandy loams and peats are best.

On account of their hardiness carrots may be seeded as early in the spring as the ground can be worked. Succession plantings at intervals of 3 weeks will insure a continuous supply of tender carrots.

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[9] Information on the storage of this and other root crops may be obtained from Farmers' Bulletin 879, Home Storage of Vegetables.

The application of coarse manure immediately before the carrot crop is planted is not advisable, as it makes the roots prongy and rough. Commercial fertilizer should be used. Planting distances are given in table 3. Carrot seed should be covered about one-half inch on most soils; on heavy lands the depth should be less, usually about one-fourth inch. With care in seeding, little thinning is necessary, as carrots will stand some crowding, especially on loose soils. They should be no thicker than 15 to 20 plants per foot of row.

Chantenay, Nantes, and Danvers Half Long are standard sorts. Carrots should be stored before hard frosts occur, as the roots are injured by cold.

CELERIAC

Celeriac, sometimes called turnip-rooted celery, has been developed for the root instead of the top. Its culture is the same as that of celery, and the enlarged roots can be used at any time after they attain sufficient size. Celeriac may be stored for winter use, but only the late summer crop should be used for storage. In regions having mild winters the roots may be left in the ground and covered with a mulch of several inches of straw or leaves, or they may be lifted and packed in moist sand and stored in a cool cellar.

CHERVIL

Two distinct types of chervil are cultivated, the so-called salad chervil and the turnip-rooted chervil. The first is used for garnishing and for other purposes instead of parsley; by many it is considered superior to parsley. Its culture is practically the same as that of parsley. The seeds must be bedded in damp sand for a few weeks before being sown, otherwise their germination is very slow.

Turnip-rooted chervil thrives in practically all parts of the country where fertile soil and sufficient moisture are to be had. In the South the seeds are usually sown during the fall but may not germinate until spring. In the North the seeds are sown during the autumn to germinate in the spring, or the plants are started indoors during late winter and transplanted to the open ground later on. Burying the seeds for a few weeks in damp sand materially hastens germination. Its spacing and culture are about the same as for beets and carrots. Tables 1 and 2 give the approximate planting dates and the usual spacing of the crop.

DASHEEN

The dasheen is closely related to the ordinary elephant ear. It is a long-season crop adapted for culture only in the lower South, where there is normally a very warm frostless season of at least 7 months. It needs a rich loamy soil, an abundance of moisture with good drainage, and a fairly moist atmosphere. In portions of the South where it is adapted the dasheen is coming into prominence as a home and truck garden crop. Small tubers, those from 2 to 5 ounces in weight, are used for planting in much the same way as potatoes. Planting may be done two or three weeks before frosts are over, and the season may be lengthened by starting the plants indoors and setting them out after frost is past. The dasheen is a large-growing plant, similar in appearance to the well-known elephant ear, and the plants should be set in 3½- to 4-foot rows about 2 feet apart in the row. Dasheens may be dug and dried on the ground in much the same way as sweetpotatoes, and stored at 50° F. with ventilation. They are cooked and used in much the same way as potatoes.

JERUSALEM ARTICHOKE

The Jerusalem artichoke is of interest to gardeners as a substitute for potatoes, but its tendency to become a weed should cause some caution in starting it. It is a near relative to the sunflower and can be grown practically throughout the United States. It is started from pieces of the tubers in the same way as potatoes. A quart of the tubers will set about 30 hills. The tubers are not injured by freezing and may remain in the ground over winter. Approximate planting dates are given in table 1.

PARSNIP

The parsnip is adapted to culture over a wide portion of the United States. While it must have warm soil and weather at planting time, it does not thrive in midsummer in the South, as the temperatures seem to be too high for it. Approximate dates for planting are given in table 1. While both soil and weather conditions must be taken into account in selecting a planting date, some consideration must also be given to the length of the growing season. In many parts of the South parsnips are grown and used during early summer, but it would not pay to plant them at a season when they would come to maturity during midsummer. Moreover, it is difficult to obtain good germination during the summer, which limits their culture during the autumn. In the North it does not pay to plant parsnips too early or to give them too long a growing season, as they are liable to become oversize, tough, and fibrous.

Any deep fertile soil will grow parsnips, but those of a light, friable nature with no tendency to bake are best. Old garden land, spaded or plowed to a depth of about a foot and well enriched with fine well-rotted manure and commercial fertilizer, is almost ideal. Stony or lumpy soils are objectionable, as they are inclined to cause rough, prongy roots. Nor is coarse manure in direct contact with the roots advisable, for the same reason.

Spacing and seeding rates are given in table 3. Parsnip seed must be fresh—that is, not over a year old—and it is well to sow rather thickly and thin to about 3 inches apart. Parsnips germinate slowly, but it is possible to help germination by covering the seed with leaf mold, sand, a mixture of sifted coal ashes and soil, peat, or some similar material that will not bake. Rolling the soil over the row or trampling it firmly after seeding usually hastens and improves germination. Boards are sometimes laid over the rows until the plants begin to come up. Hollow Crown and Guernsey are suitable varieties. The cultivation of parsnips is the same as that for similar crops.

Parsnips may be dug and stored in a cellar or pit or left in the ground until used. Roots placed in cold storage gain in quality faster than those left in the ground, and freezing in the ground in winter improves the quality. There is no basis for the belief that parsnips that remain in the ground over winter and start growth in the spring are poisonous. The reported cases of poisoning from eating so-called wild parsnips have all been traced to water hemlock (Cicuta), which belongs to the same family. The plant resembles the parsnip somewhat, and anyone should be very careful in gathering wild plants of this description.

POTATO

Any good, well-drained garden soil is suitable for potato production. The crop needs much fertilizer and well-rotted manure. High-grade complete fertilizer may be advantageously applied to most soils for potatoes. Rates of application may be about the same as for other heavy-feeding vegetables, such as onions and cabbage. Preparation of soil for potatoes should be the same as for general garden crops.

In preparing seed potatoes it is desirable to cut them into blocky rather than wedge-shaped pieces. If good seed is scarce and high priced, it may be permissible to cut to single-eye pieces, provided the seedbed is especially well prepared and the conditions for germination are satisfactory. It should be remembered that the smaller the size of the seed piece the more necessary it becomes to have the growing conditions as favorable as possible.

Early potatoes should be planted as soon in the spring as the land can be worked, irrespective of locality. Late potatoes, extensively grown in the North, should be planted late in May or during June. The rows should be not less than 2 feet nor more than 3 feet apart and the hills 10 to 15 inches apart in the row. Lay off the rows with a one-horse plow or lister and drop the seed in the bottom of the furrow. Cover the seed to a depth of about 4 inches, using a hoe or a one-horse plow. One to three weeks will be required for the potatoes to come up, depending entirely upon the temperature of the soil. The ground may freeze slightly after the planting has been done, but so long as the frost does not reach the seed potatoes no harm will result, and growth will begin as soon as the soil becomes sufficiently warm. Yields of potatoes may be materially increased by the use of certified seed that is relatively free from virus and other diseases. Certified seed is now sold by seedsmen and dealers almost everywhere, and its cost is only slightly above that of seed that has been grown without inspection or certification.

As soon as the potatoes appear above ground and the rows can be followed, the surface soil should be well stirred by means of one of the harrow-toothed cultivators. Good cultivation should be maintained throughout the growing season, with occasional hand hoeing, if necessary, to keep the ground free from weeds. After the vines begin to die, the soil may be well worked up around the plants in order to hold them erect and protect the tubers from the sun.

After the potatoes are dug they should not be allowed to lie exposed to the sun or to any light while in storage, as they soon become green and unfit for table use. Early potatoes especially should not be stored in a damp place during the heat of summer and will keep best if covered with straw in a cool, shady shed until autumn weather sets in, after which they can be placed in a cellar or buried in the open ground. The ideal temperature for keeping potatoes is between 40° and 45° F., but they will not withstand any freezing.[10]

RADISH

Radishes are hardy but they cannot withstand heat. In the South they do well during the autumn, winter, and spring, but do not thrive in summer. In the North they may be grown in the spring and autumn, and in sections having mild winters they may be grown in coldframes at this season. In high altitudes and in northern locations having cool summers they will thrive from early spring to late autumn.

Radishes are not sensitive to the type of soil, so long as it is rich, moist, and friable. Fertility from decayed manure and commercial fertilizer is essential. Some additional fertility applied when the seeds are sown is advisable, as conditions must be favorable for quick growth. Radishes that grow slowly have a pungent flavor and are undesirable.

Radishes mature the quickest of our garden crops. They remain in prime condition only a few days, and the gardener should plan to make small plantings every 2 weeks. A few yards of row will supply all the radishes a family will consume during the time they are at their best. Tables 1, 2, and 3 give approximate planting dates, rates of seeding, and spacing. Care in spacing the seeds saves labor in thinning.

There are two types of radishes, the mild, small, quick-maturing sorts, such as Scarlet Globe, French Breakfast, and Cincinnati Market, all of which reach edible size in from 20 to 40 days; and the more pungent, large, so-called winter radishes, such as Long Black Spanish and Rose China, which require 75 days or more for growth. These latter are planted so as to reach a desirable size in the autumn and are gathered and stored like other root crops. Winter radishes deserve the attention of more gardeners.

SALSIFY

Salsify, or vegetable oyster, has a wide adaptation and may be grown in practically all parts of the country. It is very similar to parsnips in its requirements but needs a slightly longer growing season. For this reason it cannot be grown as far north as parsnips. Salsify, however, is somewhat more hardy and can be sown earlier in the spring.

Soil for salsify should be thoroughly pulverized to a depth of at least a foot. If heavy, the garden soil should be lightened by adding sifted coal ashes, sand, or some other material. Like parsnips, salsify must have plenty of plant food, but fresh, rough manure should be avoided, as this causes rough, prongy roots.

Sandwich Island is the best-known variety. An ounce of seed will sow a 100-foot row, and a 50-foot row will meet the requirements of most families. As salsify seed retains its vitality only 1 year, fresh seed should always be used. Approximate dates for sowing are given in table 1. Width of rows, depth of planting, and the stand in the rows are given in table 3.

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[10] For additional information on potatoes, consult the following Farmers' Bulletins: No. 1205, Potato Production in the South; No. 1064, Production of Late or Main-Crop Potatoes; No. 1371, Diseases and Insects of Garden Vegetables; No. 879, Home Storage of Vegetables; No. 847, Potato Storage and Storage Houses.

Cultivation is the same as for other root crops. Salsify may be left in the ground over winter or lifted and stored like parsnips or other root crops. This fine vegetable should be grown more generally.

SWEETPOTATO

The sweetpotato is of tropical origin and succeeds best in the South. It is grown in home gardens as far north as southern New York and Michigan. Even farther north, in sections having especially mild climates, such as the Pacific Northwest, sweetpotato culture is possible. In general, sweetpotatoes may be grown in any locality where there is a frost-free period of about 150 days with relatively high temperature. The plant succeeds with a minimum supply of moisture, differing in this respect from many other home-garden vegetables.

A well-drained, moderately deep sandy soil of medium fertility is best for sweetpotatoes. Very deep, open soils encourage the formation of long stringy roots and should be avoided. To improve drainage the plants usually are set on top of wide ridges. For best results the soil should be moderately fertilized throughout, but most areas that have been used for home gardening probably will produce a good crop of sweetpotatoes without additional fertilization. A little well-rotted manure and some commercial fertilizer may be advantageously applied to poor soils. If applied under the rows, both manure and fertilizer should be well mixed with the soil.

Toward the northern part of the area over which sweetpotatoes are grown it is necessary to start the plants in a hotbed, because the season is too short to produce a crop after the weather warms enough to start plants out of doors. The roots too small for marketing are used for seed, bedded close together in the hotbed, and covered with about 2 inches of sand or fine soil such as leaf mold. The seed should be bedded about 5 or 6 weeks before it is safe to set the plants in the open ground. Toward the last the hotbed should be ventilated freely to harden off the plants.

The ridges for planting sweetpotatoes should be 3 to 5 feet apart and the plants about 14 inches apart in the row. Cultivate sufficiently to keep the surface soil loose and free from weeds. As soon as the vines cover the ground no cultivation is necessary.

Sweetpotatoes are dug as soon as the vines are nipped by frost. They should be dug on a bright, drying day, when the soil is not too wet. On a small scale they may be dug with a spading fork, great care being taken not to bruise or injure the roots. The roots should lie exposed for 2 or 3 hours to dry thoroughly, after which they may be placed in a warm, well-ventilated room to cure for several days. The proper temperature for curing is 80° to 90° F. for about 10 days, and then store them at 50° to 55° afterwards. A small crop may be cured around the kitchen stove and later stored in a dry room where there is no danger of their becoming too cold. Sweetpotatoes should be handled as little as possible, especially after they are cured.[11]

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[11] For additional information on sweetpotatoes, the following Farmers' Bulletins may be consulted: No. 999, Sweet-Potato Growing; No. 1059, Sweet-Potato Diseases; No. 1442, Storage of Sweet Potatoes; and No. 879, Home Storage of Vegetables.

TURNIP AND RUTABAGA

Turnips and rutabagas are similar and are treated together. They are among the most commonly grown and widely adapted root crops in the United States. Being essentially cool-weather vegetables, they are grown in the South chiefly during the fall, winter, and spring, while in the North their culture is confined largely to the spring and autumn. Rutabaga does best in the more northerly locations, and gardeners south of the latitude of Indianapolis, Ind., or northern Virginia are advised to grow turnips instead.

Turnips reach a good size in from 60 to 80 days, but rutabagas need about a month longer. Being susceptible to heat and hardy, these crops for fall use should be planted as late as possible, allowing time for maturity before hard frost. In the South, turnips are very popular during the winter and spring, but in the North July seeding following early potatoes, peas, or spinach is usually practiced.

Both turnips and rutabagas need a fertile soil. However, land that has been in some heavily fertilized crop, such as early potatoes, usually gives a good crop without additional fertilization. The soil need not be prepared deeply, but the surface should be fine and smooth. For spring culture, row planting similar to that described for beets should be practiced. The importance of planting turnips as early as possible for the spring crop is emphasized. When seeding in rows, cover the seeds lightly; and when broadcasting, rake the seeds in with a garden rake. A half ounce of seed will sow a 300-foot row or broadcast 300 square feet. Turnips may be thinned as they grow, and the tops used for greens.

Although there are both white-fleshed and yellow-fleshed varieties of turnips and rutabagas, most turnips are white fleshed and most rutabagas yellow fleshed. Purple Top White Globe is the most popular white-fleshed turnip and Golden Ball or Orange Jelly the most popular yellow-fleshed variety. American Purple Top is the commonly grown yellow-fleshed rutabaga and Sweet or White Russian or German the most widely used white-fleshed variety.

TURNIP-ROOTED PARSLEY

The root is the edible portion of turnip-rooted parsley. It has a superficial resemblance to the parsnip, and the flesh is whitish and dry, with much the same flavor as celeriac. It is boiled and used like celeriac or other root crops.

Turnip-rooted parsley requires the same climate, soil, and culture as parsley. It is hardy and able to withstand much cold, but is difficult to start in dry, hot weather. The seeds are small and usually germinate slowly. It is well to soak them in water overnight before sowing and to mix them with dry sand to obtain better distribution in the rows. The plants should be thinned to about 3 inches apart in the rows. Planting dates and spacing are given in tables 1 and 3. This vegetable may remain in the ground until after hard frosts. It may be lifted and stored like other root crops.

VINE CROPS (CUCURBITS)

The vine crops, including cucumbers, muskmelons, pumpkins, squashes, watermelons, and citrons are grouped together because of the similarity of their culture. In importance to the home gardener they do not compare with some other groups, especially the root crops and the greens, but there is a place in most gardens for at least bush squashes and a few hills of cucumbers. In large gardens a few hills of muskmelons and watermelons are often desirable.

CUCUMBER

The cucumber is distinctly a warm-weather crop. It may be grown during the warmer months over a wide portion of the country, but it is not adapted to winter growing in any but a few of the most southerly locations. Moreover, the extreme heat of midsummer in some locations is too severe, and cucumber culture in these regions is limited to spring and autumn. Tables 1 and 2 give the approximate dates when cucumbers may be planted in the various sections.

The cucumber demands an exceedingly fertile, mellow soil. In addition to the manuring and fertilization suggested in an earlier portion of this bulletin, some well-rotted manure and commercial fertilizer is advisable under the rows or hills, but the gardener should be sure that the manure contains no remains of any vine crops, as these might carry injurious diseases. Three or four wheelbarrow loads of manure and 5 pounds of commercial fertilizer to a 50-foot drill or each 10 hills is enough. The manure and fertilizer should be well mixed with the top 8 to 10 inches of soil.

Cucumbers are sensitive to cold, and they should not be planted until the ground has warmed up. For an early crop the seed may be started in berry boxes, plant bands, pots, or on sods in a hotbed, and moved to the garden after danger of late frost is past. During early growth and in cool periods cucumbers and other tender plants may be covered with plant protectors made of panes of glass with a top of cheesecloth, parchment paper, or muslin. A few hills will supply the family with pickling and slicing stock, and the few precautions necessary to insure success are well repaid.

Cucumbers make a rank growth and must have plenty of room. When planted in drills, the rows should be 6 or 7 feet apart, with the plants thinned to 2 to 3 feet apart in the rows. With the hill method of planting, the hills should be at least 6 feet apart each way, with the plants thinned to two to each hill. It is always wise to plant 8 or 10 seeds in each hill, thinning to the desired stand. Cucumber seeds should be covered to a depth of about 1 inch; and if the soil is inclined to bake they should be covered with loose earth, such as a mixture of soil and sifted coal ashes, sand, or other material that will not harden and keep the plants from coming through.

When grown primarily for pickling, one of the special small-sized pickling varieties, such as Chicago Pickling or Snow's Pickling, should be used; if for slicing, such varieties as White Spine and Early Fortune should be employed. It is usually desirable to plant a few hills of each type, but the slicing type can be planted and used for both purposes.

Cucumbers require almost constant vigilance to prevent destructive attacks by cucumber beetles. These insects not only eat the foliage but also spread cucumber wilt and other serious diseases. During the early stages of growth the plants may be protected by small frames such as a wooden barrel hoop tacked to three pegs and covered with cheesecloth or mosquito netting, the edges of the netting being covered with earth to keep it from blowing off and to prevent insects from gaining entrance. The covering may be removed while cultivating, but it must be immediately replaced, as no insects should be allowed to touch the plants. When the vines begin to run, the covering must be removed. Thorough dusting with an arsenical dust every few days helps to control cucumber beetles. For the melon aphis, another serious enemy, a nicotine dust should be used, or a combined application may be made for both.[12]

The removal of the fruits before any hard seeds form materially lengthens the life of the plants and the size of the crop.

MUSKMELON

The muskmelon needs an abundance of room, and its culture in gardens where space is scarce is seldom justified. In the larger home gardens or in the home truck patch where conditions are suitable, the muskmelon is a desirable addition to the list of crops. The climatic and soil requirements of the muskmelon are about the same as for the cucumber. It seems to develop more perfectly when grown on light-textured soils, whereas the cucumber does well on moderately heavy land. The plants are vigorous growers, and the spacing should be somewhat wider than for cucumbers. Table 3 gives the width of rows and spacing.

Muskmelons are frequently started indoors in pots, berry boxes, plant bands, or in pieces of sod and transferred to the garden later. In sections where the growing season is short or earliness desired, this practice is important. Special precautions should be taken to protect muskmelons from attacks by insects. This can be accomplished as suggested for cucumbers.

Hearts of Gold, Emerald Gem, Pollock 10–25, and Tiptop are standard varieties of the common muskmelon. Several special types of melons such as the Casaba, Honeydew, and Persian are being grown to some extent in various parts of the United States. In general, these are not well adapted to home-garden culture except in certain portions of the South and West, where they are produced under irrigation.[13]

PUMPKIN

Pumpkins are sensitive to both cold and heat. In the North they cannot be planted until settled weather has arrived; in the South they do not thrive during midsummer. Approximate planting dates for different sections are given in table 1.

Most varieties of pumpkins require an abundance of room. The gardener, therefore, is seldom justified in devoting any portion of a limited garden area to pumpkins, because many other vegetables would give greater returns from the same area. However, in large gardens where there is plenty of room and where they can be planted after some early crop like potatoes, it is often possible to grow pumpkins to advantage. If planted in hills, they should be at least 10 feet apart each way, but when started among corn, potato, or other plants they are usually spaced 8 to 10 feet apart in every third or fourth row.

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[12] For additional information on cucumber culture and cucumber enemies, see Farmers' Bulletins 1563, Cucumber Growing, and 1371, Diseases and Insects of Garden Vegetables.

[13] For additional information on muskmelon culture, see Farmers' Bulletin 1468, Muskmelons.

The pumpkin is one of the few vegetables that thrives under partial shade and for this reason may be grown among sweet corn or other tall-growing plants. Small Sugar and Connecticut Field are well-known orange-yellow skinned varieties. The Kentucky Cheese has a grayish orange color with salmon-colored flesh. All are good-quality, productive varieties.

Pumpkins should be gathered and stored before they are injured by hard frosts. They keep best in a well-ventilated place where the temperature is a little above 50° F.

SQUASH

Squashes are among the most commonly grown garden plants. They may be grown in practically all parts of the United States where fertile soil with sufficient moisture is found. Soils rich in organic matter are needed. The use of well-rotted manure thoroughly mixed with the soil is recommended. Although sensitive to frost, they are more hardy than melons and cucumbers. In the warmer portions of the South squashes may be grown during the winter.

There are two classes of squash varieties, summer and winter. The former includes the Bush Scallop, known in some localities as the Cymling, and the Summer Crookneck. The winter class includes the hard-shelled, later-maturing storage varieties such as Hubbard, Delicious, and Boston Marrow. The so-called vegetable marrows are also classed as summer squashes. Italian Vegetable Marrow, or Cocozelle, is the best-known sort. All the summer squashes and the marrows must be used while young and tender, easily penetrated by the thumb nail. The winter squashes have hard rinds and are well adapted for storage.

The summer varieties, such as Crookneck and Bush Scallop, are of the bush type and may be planted early. If in drills, the rows should be about 5 feet apart with the plants spaced 18 inches in the rows. If in hills, these should be about 4 by 4 feet with two plants in each hill. Such varieties as Boston Marrow and Hubbard should be in drills 10 to 12 feet apart or in hills 8 by 8 to 12 by 12 feet apart.

Summer varieties should be gathered before the seeds ripen or the rinds harden, but the winter sorts will not keep unless well matured. They should be taken in before hard frosts occur and stored in a dry, moderately warm place, such as on shelves in a basement with a furnace. Under favorable conditions such varieties as Hubbard may be kept until midwinter.[14]

WATERMELON

Like muskmelons and pumpkins, watermelons require an abundance of room, and only the larger gardeners can afford to devote space to them. Moreover, watermelons are rather sensitive to the soil on which they are grown, a sand or sandy loam being practically essential. Being warm-weather plants, it is useless to plant the seeds too early or to attempt their culture in sections where the season is too short and the temperature too low. The approximate time for planting watermelons in the different zones is given in table 1. Watermelon hills should be at least 10 feet apart; consequently a few hills take up a large amount of space. The old plan of making the hills by mixing a half wheelbarrow load of rotted manure with the soil in each hill is a good one, provided the manure is free from the remains of cucurbit plants that might carry disease. A half pound of commercial fertilizer also should be thoroughly mixed with the soil in the hill. It is a good plan to place several seeds in a ring about 1 foot in diameter in each hill. Later the plants should be thinned, two to each hill.

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[14] For additional information on squashes and pumpkins, ask for the mimeographed circular on these subjects prepared by the Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

Kleckley Sweet, Florida Favorite, Stone Mountain, and Tom Watson are suitable varieties for the home garden.

The preserving type of watermelon, called citron, is not edible when raw. Its culture is the same as that for the watermelon.

LEGUMES

Beans and peas are among our oldest and most important garden plants. They contain large quantities of fats and proteins, and only a limited space is required for growing the family supply. Both beans and peas, especially in the fresh green state, as one can have them from the home garden, are among the richest sources of vitamins A, B, and C. Recent investigations have revealed that they also contain other beneficial vitamins. The popularity of both beans and peas is also due in part to their wide climatic and soil adaptation.

BEANS

From the home gardener's point of view green beans, both snap and Lima, are of more importance than dry beans. Green snap beans are among the most important vegetables grown in the garden. In the North snap beans cannot be planted until the ground is thoroughly warm, but succession plantings may be made every 2 weeks from that time until a few weeks before frost. In the South and Southwest green beans may be grown over a wide portion of the fall, winter, and spring seasons, but they are not well adapted to midsummer. In the extreme South beans are grown throughout the winter. The approximate dates for planting beans in the different zones are given in table 1, and the spacing and quantity of seed needed are shown in table 3.

Green beans are not especially sensitive to the character of the soil upon which they are grown, as long as it is well drained, reasonably fertile, and of such physical nature that it does not interfere with germination and emergence of the plants. Soil that has received a general application of manure and fertilizer should need no additional fertilization. When beans follow early crops that have been fertilized the residue of this fertilizer is usually sufficient for the beans.

As it develops, the bean plant pushes the two halves of the seed, or cotyledons, through the surface, and heavy-textured soils that bake are liable to interfere seriously with or prevent normal development. On heavy lands it is well to cover the seeds with sand, a mixture of sifted coal ashes and sand, peat, leaf mold, or some other material that will not bake. By keeping the surface of the ground moist but not too wet for a few days after planting the plants may be brought up without difficulty. It is very important that bean seed be covered not more than 1 inch in heavy soils and 1½ inches on sandy soils. Beans are sensitive to cold and should never be planted until the soil has warmed up and the weather is settled. The dates given for planting beans and other tender crops must often be changed to suit the season. When beans are planted in hills they may be covered with plant protectors, thereby making it possible to plant somewhat earlier than otherwise.

Stringless Green Pod, Tendergreen, Pencil Pod Black Wax, and Round Pod Kidney Wax are good bush varieties for snap beans. Brown-seeded or white-seeded Kentucky Wonders are the best pole varieties for snap pods. White Navy, White or Red Kidney, and Dwarf Horticultural are excellent varieties for dry-shell purposes.

Two types of lima or so-called butter beans are grown in home gardens. In the North the large lima (*Phaseolus lunatus macrocarpus*) is most generally grown. In the South the Sieva or Carolina type is mainly grown. Certain more northerly sections of the United States, including northern New England and the northern portions of the States along the Canadian border, are not adapted to the culture of lima beans. Lima beans should have a growing season of about 4 months with relatively high temperature and cannot be planted with safety until somewhat later than snap beans. Weather and soil conditions must be suitable before it is safe to put the seeds in the ground. The small butter beans will mature in a shorter period than the large-seeded lima beans. By starting the seed indoors in berry baskets or other containers and moving them to the open ground when the weather is settled, a little may be gained in earliness. The use of plant protectors over the seeds will also aid in obtaining earliness. In the South planting dates depend upon location. In the lower South, however, midsummer plantings are seldom practicable, and in the northerly portions planting is restricted to spring and early summer.

Lima beans may be grown on almost any fertile, well-drained, mellow soil, but it is especially desirable that the soil be light-textured and not subject to baking, as the plants cannot force their way through a hard crust. Covering with some material that will not bake, as suggested for other beans, is a wise precaution when using heavy soils. Lima beans need a soil somewhat richer than is necessary for kidney beans, but the excessive use of manure or fertilizer containing a high percentage of nitrogen should be avoided. Beans do well when supplied with a fertilizer containing a relatively high proportion of phosphoric acid.

Both the Sieva and the large lima are to be had in pole and bush forms. Bush beans may be drilled in rows like green beans; pole Lima beans require more room than the bush forms. Precautions must be taken to avoid covering lima bean seed to deep. From 1 inch to 1½ inches is about the right depth.

In the South, Henderson Bush Lima, and the Sieva or Carolina pole are commonly used; in the North, Henderson, Fordhook, and Burpee are the common bush limas and Siebert, King of the Garden, and Large Green Seeded are the popular pole varieties.

Pole beans of the kidney and lima types require some form of support, as they normally make vines several feet long. The well-known bean pole consisting of a small sapling about 2 inches in diameter at the base and 6 or 7 feet long is very satisfactory. Sawed stakes are objectionable on account of the corners and their smoothness, which makes it difficult for the beans to climb. Beans usually need some help in getting started up the poles. They twine in a counterclockwise direction. Where poles are difficult to obtain beans may be trained to a trellis made of a top and bottom wire stretched between posts and connected every foot or two by stout twine. Some gardeners plant pole beans along the fence or beside hills of corn, which serve as supports.

The only special precaution to observe in cultivating beans is to avoid cultivating or handling the vines while wet, as this is liable to spread disease. The advent of the Mexican bean beetle in the East has brought the home gardener in these sections face to face with a difficult problem. Spraying or dusting is recommended.[15]

PEAS

Peas have many of the merits possessed by beans. They are high in food value and rich sources of vitamins A, B, and C. They require more space than beans, and with limited garden areas only an early planting may be practicable. Fresh-picked peas are so superior in quality to those that have been off the plants for some time that every gardener who has the space and can grow them should include peas in his list of vegetables.

Peas are distinctly a cool-weather crop. In the lower South they are grown at all seasons except during the summer; farther north the seasons for peas are spring and autumn. In the northern tier of States and at high altitudes they may be grown from spring until autumn, although in many places summer heat is too severe and the season is practically limited to spring. Table 1 gives the approximate date for planting peas in the different zones. A good general rule to follow in portions of the South where freezing does not occur is to plant at any time except in the warmer months. In the North the best general rule is to plant as early as the ground can be worked, and a few succession plantings may be made at 10-day intervals. The later plantings rarely yield as well as the earlier ones. Plantings may be resumed as the cool weather of autumn approaches, but the yield is seldom as satisfactory as that from the spring crop. Planting distances and depth of covering for peas are given in table 3.

Alaska and other early smooth-seeded varieties are frequently used for planting in the early spring because of their supposed ability to germinate well in cold, wet soil. Laxton Progress, Hundredfold, and Little Marvel are recommended as suitable early varieties with wrinkled seeds. Giant Stride and Stratagem are approximately 2 weeks later than Progress, but under favorable conditions will produce very heavy yields. Those who wish to grow a pea requiring brush or trellis will find no better late variety than Alderman (Telephone). Some early varieties like Gradus, World Record, and Thomas Laxton will produce a somewhat larger crop if grown on supports.

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[15] For information on insects and diseases of beans, see Farmers' Bulletin 1371, Diseases and Insects of Garden Vegetables. For information on the Mexican bean beetle and its control, see Farmers' Bulletin 1624, The Mexican Bean Beetle in the East and Its Control.

CABBAGE GROUP

The cabbage or cole group includes heading broccoli, sprouting broccoli, brussels sprouts, cabbage, Chinese cabbage, cauliflower, collards, and kohlrabi. These plants are noteworthy because of their adaptation to culture in most portions of the country where fertile soil and sufficient moisture are to be found and because of their hardiness to cold and richness in vitamins A, B, and C. Altogether they are among the most valuable of the home-garden crops.

HEADING BROCCOLI

Heading broccoli is similar to cauliflower in appearance—even being marketed as cauliflower—but it needs a much longer period for development. In the South and certain portions of the West, broccoli plants may be set in summer and autumn and come to edible maturity during late winter and early spring. In the colder portions of the North it will not live over winter, and the growing season is not long enough for most varieties of broccoli. Early Large White French is one of the best-known varieties. In soil and cultural requirements broccoli is similar to cauliflower.

SPROUTING BROCCOLI

Sprouting broccoli is a kind that forms a loose flower head upon a tall, fleshy, branching stalk instead of compact heads or curds as in the case with both cauliflower and heading broccoli. This is one of the newer vegetables to most American gardeners, but it has been known and appreciated by Europeans for many years.

Sprouting broccoli is adapted to winter culture in regions suitable for wintering-over cabbage. It is also very resistant to heat. Spring-set plants in the latitude of Washington, D. C., have yielded good crops of sprouts until midsummer and later, under conditions that caused cauliflower to fail. In the latitude of Norfolk, Va., the plant has yielded good crops of sprouts from December until spring. It is an exceptionally promising home-garden crop.

Sprouting broccoli is grown in the same way as cabbage. Plants grown indoors during the early spring and set in the open about April 1 begin to yield sprouts about 10 weeks later. The fall crop may be handled in the same way as late cabbage, except that the seed is sown later. The sprouts carrying flower buds are cut about 6 inches long, and other sprouts arise in the axils of the leaves so that a continuous harvest may be obtained. The habits of growth are shown in figure 19. Italian Green Sprouting is one of the best-known varieties or strains.

BRUSSELS SPROUTS

Brussels sprouts are somewhat more hardy than cabbage and will live outdoors over winter in all the milder sections of the country. It may be grown as a winter crop in the South and as early and late cabbage in the North. The sprouts, or small heads, are formed in the axils of the leaves (fig. 20). As the heads begin to crowd, the lower leaves should be broken from the stem of the plant to give them more room. The top leaves should always be left, as the plant

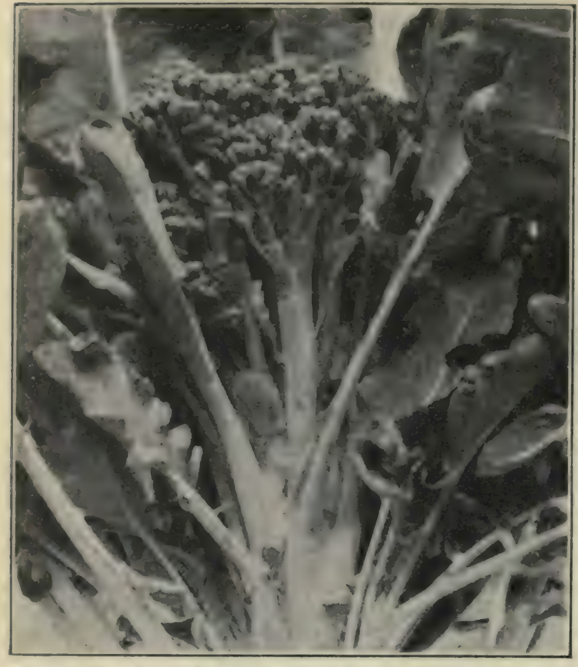

FIGURE 19.—Sprouting broccoli, a worth-while addition to the list of garden vegetables.

needs them to supply nourishment. For winter use in cold climates, take up the plants that are well laden with heads and set them close together in a pit, a coldframe, or a cellar with some soil tamped around the roots. Keep the stored plants as cool as possible without freezing.

CABBAGE

Because of its wide climatic and soil adaptability and its popularity as a food, cabbage undoubtedly ranks as one of the most important home-garden crops. In the lower South it can be grown in all seasons except during the summer, and in latitudes as far north as Washington, D. C., it is frequently set during the autumn, as its extreme hardiness enables it to live over winter at relatively low temperatures and thus become available among the first garden crops of spring. Farther north it can be grown as an early summer crop and as a late fall crop for storage. Unlike many other garden crops, cabbage can be grown throughout practically the entire United States where suitable soil and sufficient moisture are to be found.

Cabbage is not at all sensitive to the type of soil on which it is grown so long as the land is very fertile, of good texture, and moist. Cabbage is a gross feeder, and no vegetable will make a greater or more rapid response to favorable growing conditions. Quality

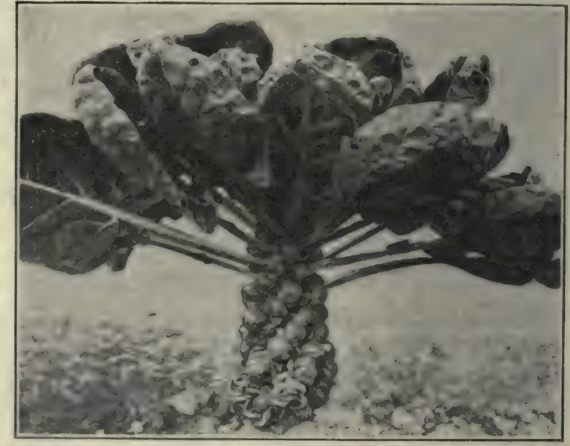

FIGURE 20.—Brussels sprouts. The sprouts are borne in the axils of the leaves.

in cabbage is closely associated with quick growth, and both rotted manure or compost and commercial fertilizer should be liberally used. In addition to the applications made at planting time, cabbage may also receive a side dressing or two of nitrate of soda, sulphate of ammonia, or some other quickly available nitrogenous fertilizer. These may be applied sparingly to the soil around the plants at intervals of 3 weeks, not more than 1 pound being used to each 200 square feet of space, or, in terms of single plants, a third of an ounce to each plant. For late cabbage the soil should not be so rich, and the supplemental feeding with nitrates may be omitted.

Good seed is especially important. Only a few cents' worth of seed is needed for starting enough plants for the home garden, as 2 or 3 dozen heads of early cabbage are as many as the average family can use. Early Jersey Wakefield and Charleston Wakefield are standard early sorts. Copenhagen Market and All Seasons are excellent midseason kinds, while for late cabbage Flat Dutch and Danish Ball Head are largely used.

Where cabbage yellows is a serious trouble, resistant varieties should be used. The following are a few of the wilt-resistant varieties adapted to different seasons: Wisconsin Hollander, for late storage; Wisconsin All Seasons, somewhat earlier, a kraut cabbage; Marion Market, for midseason, a round-head cabbage; Globe, for midseason, a round-head cabbage.

Cabbage plants for spring setting in the North may be grown in hotbeds or greenhouses from seeding made a month to 6 weeks before planting time, or may be purchased from southern growers who produce them outdoors during winter. These winter-grown, hardened plants, sometimes referred to as "frostproof", are hardier than hotbed plants and may be set outdoors in most portions of the North as soon as the ground can be worked in the spring. Northern gardeners can have cabbage from their gardens much earlier by using healthy southern-grown plants or well-hardened, well-grown hotbed, or greenhouse plants. Late cabbage, prized by northern gardeners for fall use and for storage, is grown from plants produced in open seedbeds from sowings made about a month ahead of planting. Late cabbage may well follow early potatoes, peas, beets, spinach, or some other early crop. Many gardeners set cabbage plants between potato rows before the potatoes are ready to dig, thereby gaining time. The approximate date for setting cabbage plants is given in table 1. In protected locations or if plant protectors are used, it is possible always to advance dates somewhat, especially if the plants are well hardened. Planting distances for cabbage are given in table 3.[16]

Late cabbage is one of the most satisfactory vegetables for storage for winter. The heads may be cut and packed in a barrel or a box buried in the ground or covered with soil, or the plants may be pulled and buried in a low windrow.

CHINESE CABBAGE

Chinese cabbage, which is closely related to both cabbage and turnips, is variously known as pai tsai, petsay, pe-tsai, pok choi, wong bok, etc. The name celery cabbage is popularly applied to it, although it is unrelated to celery. Another form, which might be called the nonheading type of Chinese cabbage, has been erroneously called white Chinese mustard. It does not form a head, but is grown for a potherb. The nonheading types are popular and deserve greater attention.

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[16] Complete information on the culture, storage, and enemies of cabbage is to be found in Farmers' Bulletins No. 879, Home Storage of Vegetables, and No. 1371, Diseases and Insects of Garden Vegetables, and in Circular 252, Commercial Cabbage Culture.

Chinese cabbage seems to do best as an autumn crop in the northern tier of States. When full grown, it is an attractive vegetable. It is not especially successful as a spring crop, and gardeners are advised to confine their attention to its fall culture in the North and its winter culture in the South.

The plant demands a very rich, well-drained but moist soil. The seeds may be sown and the plants transplanted to the garden, or they may be drilled in the garden rows and the plants thinned to the desired stand. For the fall crop in the North, about 2½ months before frost is a good time to sow the seeds. The approximate dates for sowing are given in tables 1 and 2, and the spacing of the plants and depth of covering seeds are given in table 3.

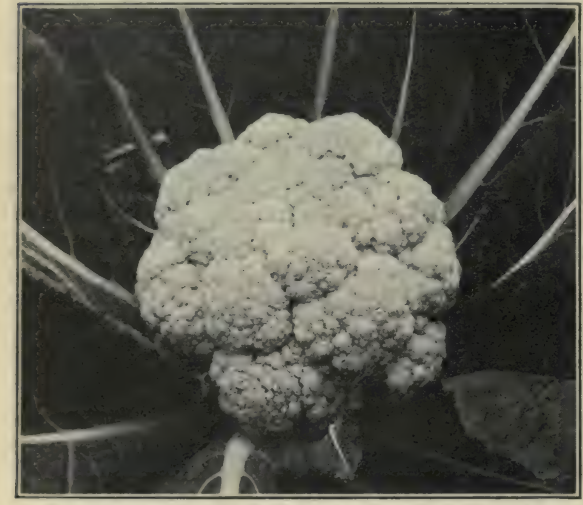

FIGURE 21.—A good head of cauliflower.

CAULIFLOWER

Cauliflower has been called "rich man's cabbage", because it is more difficult to grow. It has an attractive appearance during growth and as prepared for the table (fig. 21). Although hardy, it will not withstand as much frost as cabbage. Any considerable degree of warm weather is fatal to cauliflower, causing it to fail to head. In the South its culture is limited to fall, winter, and spring; in the North it is practically confined to spring and autumn, as the summers and winters are too severe. However, in some regions of high altitude and when conditions are otherwise favorable cauliflower culture is continuous throughout the summer. In most cases it is treated as an early and a late crop in much the same way as cabbage.

Like cabbage, cauliflower requires a fertile, well-drained soil. It is grown on all types of land from sands to clays and peats. Although the physical character is unimportant, the land must be fertile. Manure and commercial fertilizer are thus essential.

The time required for growing cauliflower plants is the same as for cabbage. In the North the main cause of failure with cauliflower in the spring is in not sowing the seed and setting the plants early enough. The fall crop must be planted at such a time that it will come to the heading stage during cool weather. Tables 1 and 2 give the approximate planting dates for cauliflower in the various zones. Snowball and Dwarf Erfurt are standard varieties of cauliflower. Care should always be taken to obtain a good strain of seed; poor cauliflower seed is especially objectionable.

The only special precaution to be observed in the culture of cauliflower is to tie the leaves together when the heads or "buttons" begin to form, in order to keep the heads white. Cauliflower does not keep long after the heads form, and a dozen or two heads are sufficient for the average gardener.[17]

COLLARDS

The culture and uses of collards are the same as for cabbage. Collards withstand the heat better than other members of the cabbage group, and they are highly esteemed in the South for both summer and winter use. Collards do not form a true head, but instead a large rosette of leaves, which may be blanched by tying together or covering.

KOHLRABI

The edible portion of kohlrabi consists of the swollen stem of the plant. The early crop in the North may be started like cabbage and transplanted to the garden. In the South kohlrabi may be grown at almost any time during the year except midsummer. The approximate dates for planting and the spacing of the plants in the rows are given in tables 1, 2, and 3. Kohlrabi seeds may be started indoors and the plants transplanted to the garden, or the seeds may be drilled in the garden rows and the plants thinned to the desired stand. In soil and cultural requirements kohlrabi is similar to cabbage. The principal requirements are fertile soil and sufficient moisture. Kohlrabi is an excellent vegetable if harvested while young and tender.

ONION GROUP

Onions and related plants are among the oldest and most popular of the home-garden crops. It would be difficult to find a home garden without at least one of this group, which includes chive, garlic, leek, onion, and shallot. Practically all of these have an exceedingly wide soil and climatic adaptation; at least some can be grown in all parts of the country where fertile soil and sufficient moisture are found.

The members of the onion group require but little garden space to produce enough for the family needs. They may be grown over a large part of the season, and dry onions are well adapted to winter storage. Moreover, these plants are good sources of vitamins A, B, and C.

CHIVES

The chive is a small onionlike plant that is used for flavoring soups and stews (fig. 22). The plants will grow in any place where onions do well. They are frequently planted as a border, but they are equally adapted to culture in rows like other vegetables. Being a perennial, chive should be planted in a place where it can be left for more than one season. The approximate planting date in different zones is given in tables 1 and 2, and spacing information is given in table 3.

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[17] For additional information on the culture of cauliflower, send for a mimeographed circular prepared by the Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

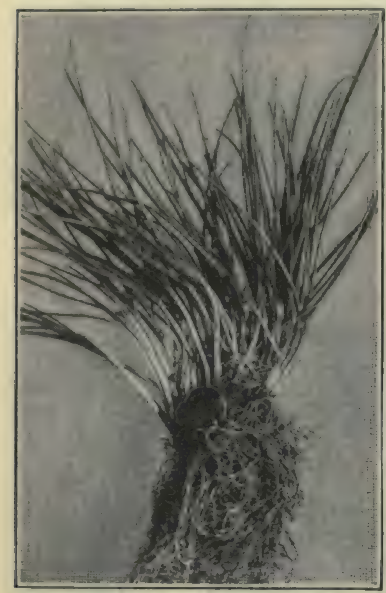

FIGURE 22.—A clump of chive.

Chive may be started from either seed or clumps of bulbs. When once established, it is an easy matter to lift some of the bulbs and move them to a new location. When left in the same place for several years they become too thick, and an occasional resetting is desirable.

GARLIC

Garlic is more exacting in its cultural requirements than are onions, but it may be grown with a fair degree of success in almost any home garden where good results are obtained with other vegetables. Like chive, garlic is of value chiefly for seasoning; and, while desirable as an addition to the list of garden crops, it must be considered of minor importance.

The approximate planting dates and spacing are given in tables 1, 2, and 3. Garlic is propagated by planting the small cloves or bulbs which make up the large bulbs. Each large bulb contains about 10 small ones. In preparing the stock for planting, the small bulbs are carefully separated and planted singly. Each will grow into a bulb containing about 10 small ones (fig. 23).

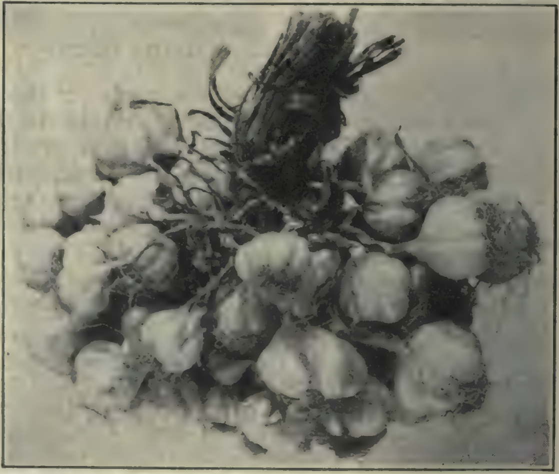

FIGURE 23.—Garlic. Each bulb contains several small ones. These are separated for planting.

The culture of garlic is practically the same as that for onions. When mature the bulbs are pulled, dried, and braided into strings or tied in bunches, which are hung in a cool, well-ventilated place for later use. In the South, where the crop matures early, care must be taken to keep the garlic under favorable conditions, otherwise it will spoil. In the North, where the crop matures later in the season, storage is not so difficult, but care must be taken to prevent freezing.

LEEK

The leek is very similar to the onion in its adaptability and cultural requirements. It forms a thick fleshy stem like a large green onion instead of a bulb (fig. 24). This is used in soups and stews and for almost any purpose to which the onion is adapted. Leeks are started from seeds like onions, but are usually sown in a trench, so that the plants can be more easily hilled up as growth proceeds. Tables 1, 2, and 3 give planting dates and spacing distances. Leeks are ready for use any time after they attain suitable size, but under favorable conditions they grow to 1½ inches or more in diameter with white stalks 6 to 8 inches long. They may be lifted in the autumn and stored like celery in a coldframe or a cellar.

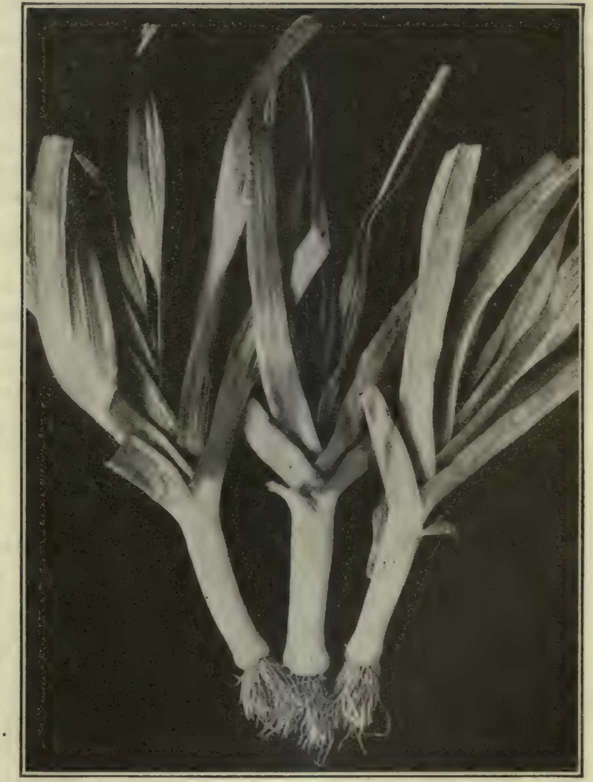

FIGURE 24.—Leek. This relative of the onion is used in soups and stews and in other ways.

ONION

The onion will thrive under a wide variety of climatic and soil conditions. It does best with an abundance of moisture and a temperate climate without extremes of heat or cold during the growing season. In the South the onion will thrive during the fall, winter, and spring. Farther north winter temperatures may be too severe for certain types; yet others, such as the Potato onion, may be planted in the autumn and be ready for use in early spring. However, in the North onions are primarily a spring, summer, and fall crop. Approximate planting dates are given in tables 1 and 2.

Any type of soil will grow onions, but it must be fertile, moist, and in the highest state of tilth. Both rotted manure and commercial fertilizer, especially one high in phosphorus and potash, should be applied to the onion plot. A pound of manure to each square foot of ground and 4 or 5 pounds of fertilizer to each 100 square feet is about right. The soil should be very fine and free from clods and foreign matter.

Onions may be started in the home garden by the use of sets, seedlings, or seed. Sets, or small onions, grown the previous year, are usually employed by home gardeners, but plants grown in an outdoor seedbed in the South or in a hotbed or a greenhouse are coming into more general use. The home-garden culture of onions from seed is quite satisfactory in the northern tier of States, where the summers are comparatively cool.

Several distinct types of onions may be used in the home garden. The Potato or Multiplier variety is planted in the fall or early spring for green onions. The Top or Tree onion is used in the same way. The Bermuda is a large, flat, mild-flavored type that is used extensively in home gardens for growing green onions and dry bulbs. Unfortunately, it is a poor keeper. The Valencia or Spanish variety and its modified form, the Prizetaker, is a large, mild-flavored, straw-colored, spherical onion that is a good keeper. The White Globe, American Silverskin, or White Portugal, and the Yellow Danvers, Southport Yellow Globe, and Southport Red Globe are varieties commonly used as sets and seed for the main or northern crop. All of them may be used for either green or dry onions.

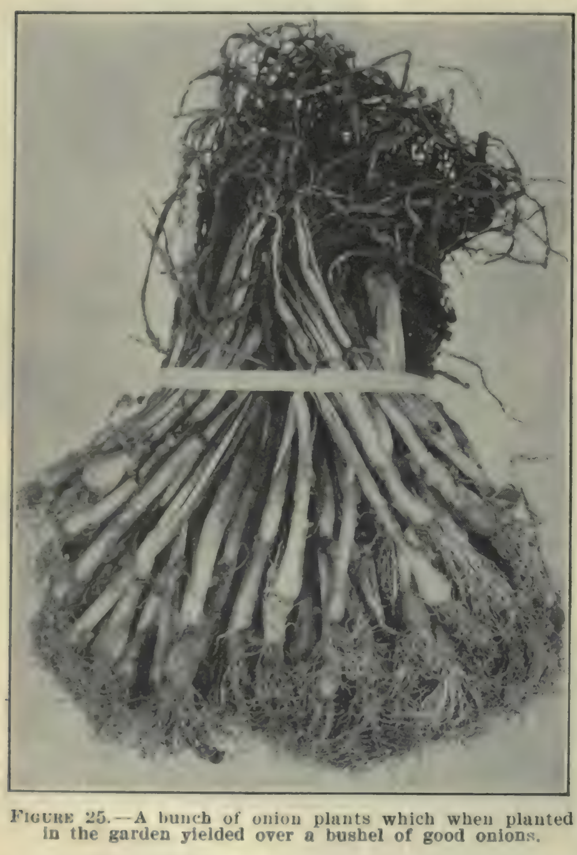

FIGURE 25.—A bunch of onion plants which when planted in the garden yielded over a bushel of good onions.

Onion sets, seedlings, or seed may be planted in rows, as suggested in table 3. The cost of sets and seedlings is about the same, but seed costs much less. In certainty of results the seedlings are best; practically none form seedstalks, and all make onions. Figure 25 shows a bunch of Prizetaker seedlings. This bunch yielded over a bushel of good onions. Seed-sown onions are uncertain unless conditions are quite favorable.

The cultivation of onions may be limited to the control of weeds. When the bulbs are well grown and the tops begin to die, the onions should be pulled and left in windows in the garden or on wire-bottom trays placed under an open shed for a few days to dry. The tops may then be removed and the onions put in a well-ventilated place to cure.

SHALLOT

The shallot is a small onion of the Multiplier type. In its requirements it is similar to other onions; and as the bulbs have a more delicate flavor than most onions, the plant is well worth attention in the garden. Shallots seldom form seed and are propagated by means of the small cloves or divisions into which the plant splits during growth. The plant is hardy and may be left in the ground from year to year, but best results are to be had by lifting the clusters of bulbs at the end of the growing season and replanting the smaller ones at the desired time. The Jersey or False shallot is the only kind available from American seedmen. Its quality is much the same as that of the True shallot.

FLESHY-FRUITED WARM-SEASON CROPS

Eggplant, peppers, and tomatoes are closely related and are similar in their cultural requirements. Warm weather and fertile, well-drained soil are essential to obtaining good results with these crops. Tomatoes are by far the most important, and a home garden without them is rarely seen. Tomatoes are one of the best sources of vitamins A, B, and C. Moreover, the fact that the canned and dried tomatoes also contain these vitamins gives the vegetable added value.

EGGPLANT

Eggplant is extremely sensitive to the conditions under which it is grown. Distinctly a warm-weather plant, it demands a growing season of from 100 to 140 days with high average day and night temperatures. The soil, also, must be well warmed up before eggplant can safely be set outdoors.

In the South, eggplants may be grown during the spring and autumn; both midsummer and winter conditions are too severe. In the North, summer culture alone is practiced. The more northerly locations, where a short growing season and low summer temperatures prevail, are unsuitable for eggplants. Tables 1 and 2 give the approximate planting dates.

Soil for the eggplant must be extremely fertile, but it is not wise to use fresh manure or large quantities of commercial fertilizer. Garden soil that is very fertile as the result of long-continued good treatment is best for eggplant. Under such conditions a few plants will yield a large number of fruits.

Eggplant seed should be sown in the hotbed, in the greenhouse, or in warm sections outdoors about 8 weeks before the plants are needed. It is important that they be kept growing without check from drying, low temperature, or other cause. They may be transplanted like tomatoes. Good plants have stems that are not hard or woody; one with a woody stem rarely develops satisfactorily. Black Beauty and Florida Highbush are good varieties.

PEPPERS

Peppers have greatly increased in popularity as a home-garden crop. Formerly looked upon as of merit mainly for seasoning, they are now used in salads, pickles, as cooked vegetables, and in many other ways.

Peppers are much like tomatoes in their requirements, but are more exacting. They may be grown over a wide portion of the United States, in locations where fertile soil and ample moisture with a relatively long growing season of high temperature are found. Being hot-weather plants, peppers cannot be planted in the North until the soil has warmed up and all danger of frost has passed. In the South planting dates vary according to the location, fall planting being practiced in some locations. Planting dates are given in tables 1 and 2.

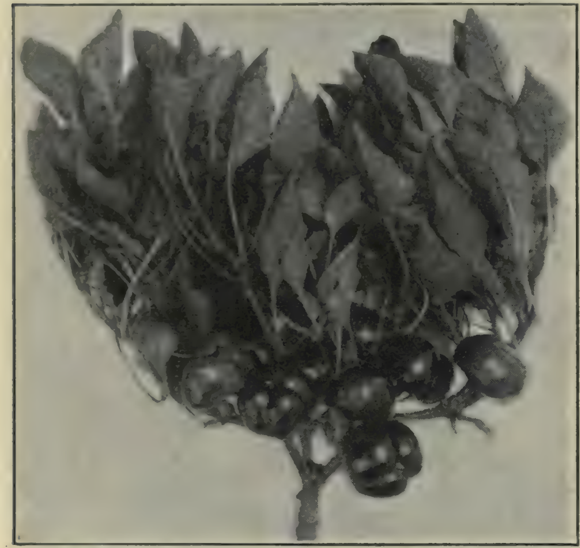

FIGURE 26.—Sunnybrook peppers, a salad variety.

Plants of peppers should be started 6 to 8 weeks before needed. The seeds and plants require a somewhat higher temperature than those of the tomato. Otherwise they are handled in exactly the same way. In the garden, peppers should be planted in rows, as specified in table 3. They need only sufficient cultivation to keep down weeds.

Hot peppers, such as are used for flavoring and sauces, are represented by varieties like Red Chile and Long Red Cayenne. For stuffing, pickles, or salad the mild-flavored Early Giant, Ruby King, Worldbeater, and California Wonder varieties mature in the order named. For slicing, like tomatoes and cucumbers, Sunnybrook (fig. 26) and Red Squash are recommended.[18]

TOMATO

The tomato is easily entitled to a place among the half dozen most important home-garden vegetables. It grows under a wide variety of conditions, requires but small space for a large production, and its value in the diet is hard to overestimate. It is one of the richest sources of vitamins A, B, and C. Of tropical American origin, the tomato naturally requires a rather high temperature.

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[18] For additional information on this vegetable, see the mimeographed circular obtainable from the Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

Home gardens in the extreme South, however, may include tomatoes during the winter. Over most of the upper South and the North it is suited to spring, summer, and autumn culture. In the more northern regions the growing season is liable to be too short for obtaining heavy yields, and in much of the North it is desirable to increase earliness and the length of the growing season by starting the plants indoors. By adopting a few precautions, the home gardener may grow tomatoes in practically all locations where there is fertile soil with sufficient moisture.

Tomatoes may be grown on any fertile, well-drained garden soil. A liberal application of manure and commercial fertilizer in preparing the soil should be sufficient for tomatoes under most conditions. In applying manure or fertilizer it is well to avoid the excessive use of such materials as poultry manure and fertilizers having a heavy proportion of nitrogen, as these might give too much vine growth and cause failure to set fruits. Heavy applications of manure and fertilizer should be broadcast, not applied in the row; but small quantities may be mixed with the soil in the row in preparing for planting.

Tomato plants should be started from 5 to 7 weeks before they are needed. Enough plants for the home garden may be started in a window box and transplanted to small pots, paper drinking cups with the bottoms removed, so-called plant bands, which are round or square, or other boxes of soil, the seedlings being spaced 2 or 3 inches apart. Tomato seed germinates best at about 70° F., or ordinary house temperature. After transplanting, tomato plants should be grown at rather low temperatures with plenty of ventilation, as in a coldframe. This gives stocky, hardy growth. If desired, tomato plants may be transplanted again to larger containers, such as 4-inch clay pots or quart cans with holes in the bottom.

Tomato plants for all but the early spring crop are usually grown in outdoor seedbeds without transplanting. Thin seeding and careful weed control will give strong, stocky plants.

For early tomatoes Earliana, Bonny Best, and Pritchard varieties are recommended. For medium and late plantings Marglobe, Globe, Greater Baltimore, and Stone are recommended. Stone is distinctly a late variety.

Tomatoes are sensitive to cold and should not be planted until danger of frost is past. By using plant protectors during cold periods the home gardener can set tomato plants somewhat earlier than would otherwise be possible. Hot, dry weather, such as occurs in midsummer in the South, is also unfavorable for planting tomatoes. Fall plantings must be made in accordance with the location. Approximate planting dates are given in tables 1 and 2. Planting distances depend on the variety and whether the plants are to be pruned and staked or not. If pruned to one stem, trained and tied to stakes or a trellis, they may be set 18 inches apart in 3-foot rows; if not, they may be planted 3 feet apart in 4-foot rows. Pruning and staking has many advantages for the home gardener. Cultivation is easier, a greater yield may be obtained from the same area, and the fruits are always clean and easy to find.[19]

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[19] For additional information on tomato culture, insects, and diseases, see Farmers' Bulletins No. 1233, Tomatoes for Canning and Manufacturing; No. 1338, Tomatoes as a Truck Crop; No. 1371, Diseases and Insects of Garden Vegetables.

MISCELLANEOUS VEGETABLES

Florence fennel, martynia, physalis, okra, and sweet corn are grouped together because they cannot be conveniently classified elsewhere.

FLORENCE FENNEL

Florence fennel is related to celery and celeriac, the enlarged, flattened leafstalks being the portion used. For a summer crop the seeds are sown in the rows in spring, and for an autumn and winter crop in the South they are sown toward the end of summer. The plants should be thinned to stand about 6 inches apart. Like most vegetables, fennel needs a fertile soil and an abundance of moisture. When the leafstalks have grown to about 2 inches in diameter the plants may be slightly mounded up and partially blanched. They should be harvested and used before they become tough and stringy. Fennel is cooked and used like celeriac and kohlrabi.

MARTYNIA

Martynia requires a good deal of heat and therefore is grown only during the warmer portion of the season. The excessive heat of southern midsummer, however, especially when accompanied by drought, is not favorable to the crop; neither is low temperature. Its growing conditions are very similar to those of cucumbers and squashes. The seeds may be started indoors and transplanted to the garden, or they may be drilled in the rows where the crop is to be grown. Planting dates and spacing are given in tables 1, 2, and 3. The fruits, gathered while young and tender, are used for pickles.

OKRA

Okra, or gumbo, has about the same degree of hardiness as cucumbers and tomatoes and may be grown under conditions suitable for them. It will thrive on any fertile, well-drained soil. An abundance of quickly available plant food will stimulate growth and insure a good yield of tender, high-quality pods.

As okra is a warm-weather vegetable, the seeds should not be sown until the soil is warm. Planting dates are given in table 1. The rows should be from 3 to 5 feet apart, depending on whether the variety is a dwarf or large growing. Seeds should be sown every few inches and the plants thinned to stand 18 inches to 2 feet apart in the rows. Perkins Mammoth, Dwarf Green Prolific, White Velvet, and Lady Finger are good varieties. The pods should all be picked young and tender, and none allowed to ripen. Old pods are unfit for use and soon exhaust the plant.[20]

PHYSALIS

Physalis, also known as groundcherry and husk tomato, is closely related to the tomato and can be grown in any location where tomatoes do well. The kind ordinarily grown in gardens produces a yellow fruit about the size of a cherry. The seeds may be started indoors or sown in the rows in the garden. Planting dates and spacing are given in tables 1, 2, and 3. The fruits are used for making preserves.

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[20] For additional information see Farmers' Bulletin 232, Okra: Its Culture and Uses.

SWEET CORN

Sweet corn, like potatoes and sweetpotatoes, requires considerable space and is adapted only to large gardens. Although a warm-weather plant, it may be grown in practically all parts of the United States. It requires a fertile, well-drained, but moist soil. With these requirements met, the type of the soil does not seem to be especially important, but a clay loam is almost ideal for sweet corn.

In the South sweet corn is planted from early spring until autumn, but the corn earworm, drought, and heat make it difficult to obtain worth-while results in midsummer. The ears pass the edible stage very quickly, and succession plantings should be made to insure a constant supply. In the North sweet corn cannot be safely planted until the ground has thoroughly warmed up. Here, too, succession plantings need to be made to insure a steady supply. Planting dates are given in tables 1 and 2. Sweet corn is frequently planted to good advantage after early potatoes, peas, beets, lettuce, or some other early, short-season crop. In some cases, to gain time, it may be planted before the early crop is removed.

Sweet corn may be grown in either hills or drills in rows at least 3 feet apart. It is well to plant the seed rather thickly and thin to single stalks 12 to 15 inches apart or three plants to each 3-foot hill. Experiments have shown that in the eastern part of the country there is no advantage in removing suckers from sweet corn. Cultivation sufficient to control weeds is all that is needed.

Maturing in the following order and in general increasing in size are the following recommended white varieties: Early Market, Howling Mob, Early Evergreen, Country Gentleman, and Stowells Evergreen. In the yellow varieties, Golden Gem, Golden Early Market, Golden Bantam, Golden Cross Bantam, and Bantam Evergreen are recommended varieties which mature in this order. A number of the new hybrid or cross-bred varieties of sweet corn are of the same size and season as some of the above-recommended varieties and in addition are highly resistant to Stewart's disease, a bacterial disease of sweet corn that has caused serious losses to growers in some sections during recent years.

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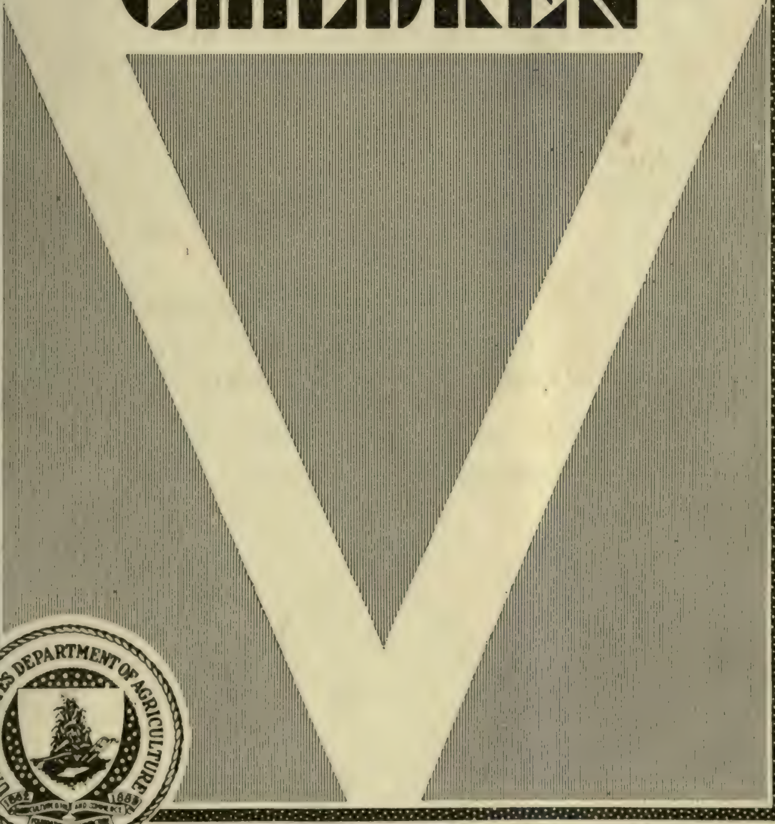
FOOD
FOR
CHILDREN

U. S. DEPARTMENT OF
AGRICULTURE
FARMERS' BULLETIN No. 1674

FOOD FOR CHILDREN



FOODS FOR GOOD NUTRITION

Does your child eat them every day?

MILK.—At least a pint; preferably a quart.
BUTTER.—At every meal.
CEREAL, BREAD, or POTATO.—At every meal.
VEGETABLES, other than potatoes.—At least two daily. One raw or quickly cooked; leafy kinds often.
FRUIT.—Once or twice a day. Citrus or other raw fruit or tomatoes daily.
EGG or MEAT.—The older child may have both.
SWEETS.—In small amounts at end of meal.

This bulletin supersedes
Farmers' Bulletin 717, Food for Young Children.

Washington, D. C. Issued September, 1931

FOOD FOR CHILDREN[1]

By Rowena Schmidt Carpenter, *Associate Specialist in Child Nutrition, Foods and Nutrition Division*, and Helen Nebeker Hann, *Assistant Home Economist, Economics Division, Bureau of Home Economics*, in cooperation with the Washington Child Research Center

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IDEAS ABOUT FEEDING CHILDREN have undergone many changes in recent years. The former tendency to keep children unduly long on a baby diet has given way to the recent practice of supplementing the milk diet early in life with a variety of wholesome foods simply prepared. The diet of the very young child differs from that of the older one mainly in the way the food is prepared and in the amounts served at various ages. Mistaken ideas passed along in families and communities have kept many good foods out of the young child's menu. This is unfortunate because good nutrition is more easily attained on a well-chosen variety than on a limited diet, and better basic food habits are established.

Begin early to give the child a carefully chosen variety of foods at regular mealtimes, and he will gradually form habits of eating that will influence his nutrition throughout life. A strong, healthy body depends upon a wholesome appetite, the right food, and good health habits from the start.

A healthy child who has an abundance of the right kinds of food grows normally and is contented and well developed. (Fig. 1.) His legs are straight and strong, and his weight is satisfactory for his build, height, and age. He has sound teeth, and hair that is glossy, smooth, and not brittle. His skin is clear, and his color is good. He has an alert expression, and bright clear eyes with no dark circles underneath. He is active and has a good appetite for his meals.

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[1] A set of eight child-feeding charts, 15 by 23 inches in size, with illustrations in black and white, is for sale by the Superintendent of Documents, Washington, D. C., for 25 cents. Enlargements of most of the photographs that appear in this bulletin illustrate the charts.

RELATION OF FOOD TO GOOD NUTRITION

The food the child eats must furnish the material for his growth and development and must meet the demands made by his ceaseless activity. Food does this in three ways: By building and repairing all parts of the body, by keeping it healthy and regulating its running order, and by furnishing the energy for work, play, and such internal functions as breathing and the beating of the heart.

BODY-BUILDING MATERIALS

The building materials required in the construction of the body are proteins, water, and minerals. Children, because they are growing rapidly, must have foods that furnish an abundant amount of these materials.

Proteins are among the most important construction materials, required as they are, not only for muscles and bones, but also for all body tissues and fluids. There are many kinds of proteins in food, some of which can be used more economically than others. Those found in milk, cheese, eggs, and meat are especially valuable for growth. The child needs a liberal supply of some of these so-called efficient protein foods every day during the years of his rapid development.

Water occurring in every living cell makes up about two-thirds of the weight of the body.

Minerals are used in the structure of all body fluids and tissues. In planning the growing child's diet three minerals, calcium, phosphorus, and iron, must have special attention because they are not abundant in all foods. A number of other mineral salts are needed too, but are so likely to be supplied in sufficient quantities in any mixed diet that it is unnecessary to mention them. Calcium and phosphorus are essential for the development of sound teeth and bones, and iron is necessary for red blood cells.

Milk is the best source of calcium and phosphorus. Most fruits and vegetables and meat also contain these two minerals, but are better sources of phosphorus than of calcium. Iron is not so widely distributed nor so abundant in foods; some, especially milk, contain only very small quantities. The foods richest in iron are egg yolk, green vegetables (especially thin green leaves), dried fruits (especially apricots, peaches, prunes, and raisins), some entire grain cereals, and lean meat. Liver, kidney, apricots, and whole wheat seem to be particularly valuable in the formation of red blood cells.

To insure good teeth and bones and to protect health, it is essential to provide enough of these sources of calcium, phosphorus, and iron daily.

BODY REGULATORS

Substances in food may fulfill more than one function. Water and minerals, because of the part they play in keeping the body in good running order, are often called regulators. Water dissolves food, carries it in the blood stream to be absorbed by cells, and is necessary in the elimination of waste products. Water is essential, too, in the regulation of breathing by keeping the air passages moist, and in the control of the body temperature through perspiration. Some of the minerals assist in the digestion and absorption of food materials and keep the muscles in good tone.

Vitamins are other important regulating substances found in food. They stimulate growth and a good appetite and help to prevent certain deficiency diseases. For example, a generous allowance of the necessary vitamins, together with satisfactory amounts of calcium and phosphorus, will prevent rickets in growing children. In rickets the bone either does not form normally or fails to grow to its full size, and bowed legs, enlarged wrist or ankle joints, beaded ribs, or malformed teeth may result. Conditions described as border-line cases of rickets may appear in children who have had diets

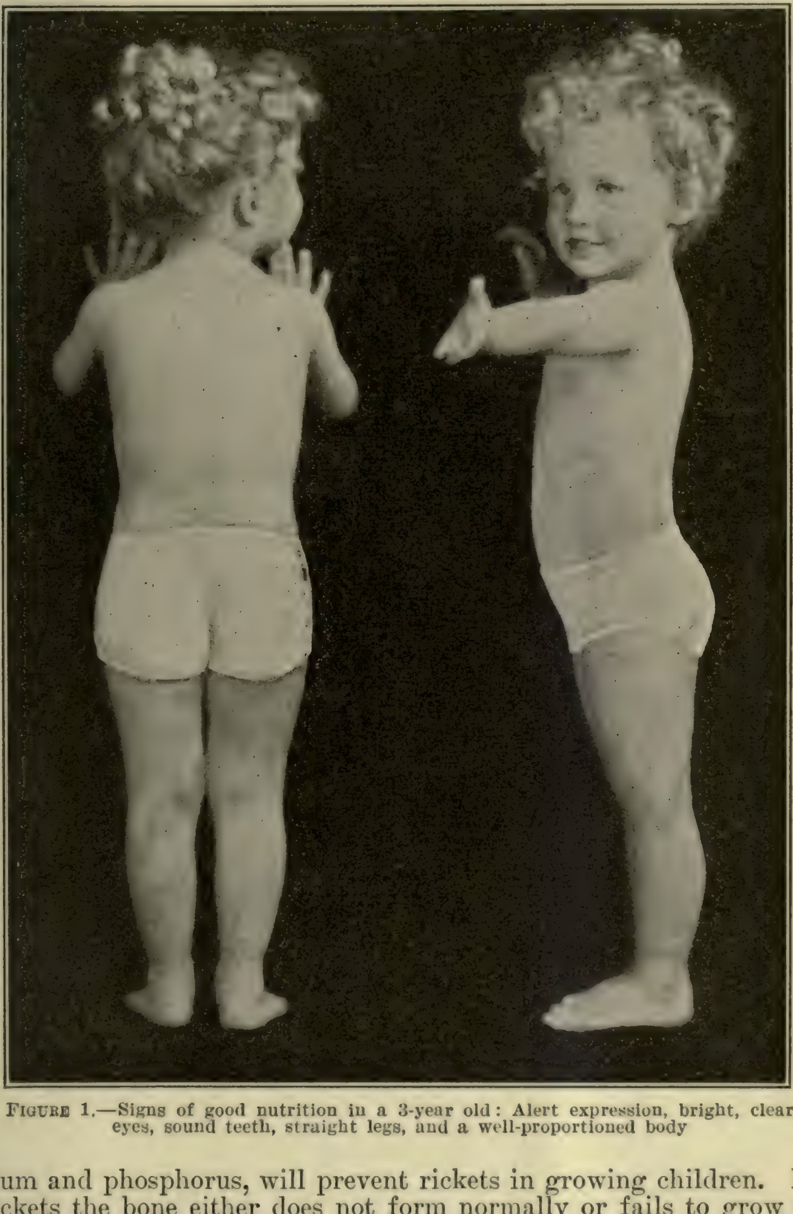

FIGURE 1.—Signs of good nutrition in a 3-year old: Alert expression, bright, clear eyes, sound teeth, straight legs, and a well-proportioned body

containing slightly less than they need of calcium, phosphorus, or the ricket-preventing vitamin.

Certain other vitamins prevent other deficiency diseases, such as pellagra and scurvy. Conditions bordering on these diseases may occur when the diet is just slightly deficient in one or two vitamins. To be protected from even a tendency towards deficiency diseases and to increase his resistance to common infections, the child must eat some foods rich in vitamins each day. Most foods in their natural state contain at least a small quantity of some of the vitamins. Therefore a varied diet made up of many fruits and vegetables, some of them raw and none of them overcooked, whole milk, butter, eggs, meat, and some entire-grain cereals, provides the child with the vitamins he needs. The list of vegetables and fruits should include green leaves, tomatoes, and citrus fruits often. Even with such variety, cod-liver oil during the winter months is a safeguard to health because it contains the important vitamins that prevent rickets and increase resistance to infections. A child who has little chance to be in the sunshine may need cod-liver oil at other times of the year, but this fact should be determined by a physician.

MATERIALS FOR ENERGY

In addition to building and regulating the body, food must provide fuel or material for energy. The child uses some energy just to carry on his internal functions, to breathe, keep his heart beating, and his blood circulating, but he uses much more for vigorous physical activity. All foods furnish some energy, but the most concentrated sources are fats, sugars, and starches. The fuel value of a food or the amount of energy it provides is measured in heat units called calories. The number of calories a child requires daily depends in general upon his size and his activity. Therefore, as children increase in size and weight and become more active, their need for energy foods grows larger. The adolescent boy and girl, because they are changing so rapidly, use more calories in proportion to size than do adults. Children of all ages need extra food when they play actively out of doors, especially in cold weather.

The appetite usually increases with these changing requirements, and most children will eat enough wholesome food to provide the energy they need. It is therefore rarely necessary to figure calories accurately in planning the child's meals. The best practical measure of sufficient calories throughout the growing period is the child's steady gain in weight.

FOODS THAT MEET BODY NEEDS

Each of the following foods or groups of foods plays its own definite rôle in meeting the day's requirement for protein, minerals, vitamins, and calories.

MILK

Milk is a good starting point in planning the child's daily diet because it is so valuable for growth. Whole milk is usually a fairly good source of vitamins. The butter fat in top milk and cream is an especially good source of one of the vitamins. Both whole and skim milk supply calcium and phosphorus. The proteins of milk are very efficient for growth. Every child should have at least a pint of milk a day. Many child-nutrition specialists recommend a quart a day to insure sufficient calcium during the years of rapid growth.

Though almost every child likes milk as such, for variety part of his daily allowance may well be used in preparing his food. For cold weather, there are milk and vegetable soups, dilute cocoa, cereal cooked in milk, and hot milk toast. On hot days children like milk sherbets, junkets, cool custards, and chilled milk flavored with fruit juice or vanilla.

Milk is filling, and must not be allowed to crowd out other necessary foods. Lack of appetite is associated with a feeling of fullness in the stomach. If milk to drink seems to impair the child's appetite, it is wise to give it toward the end of the meal, or temporarily to cut down the amount. Drinking it late in the meal rarely interferes seriously with the appetite. In certain cases it may be desirable to use powdered milk or undiluted evaported milk in cooking in order to provide the milk solids without increasing the bulk of the diet too much.

EGGS AND MEAT

Eggs and meat are good building foods. They contain efficient protein and are among the best sources of iron. The yolk of the egg is valuable also for one of the vitamins. Because of this vitamin and iron, egg yolk is one of the very early supplements of milk in the baby's diet. From about the end of the weaning period throughout the preschool years when milk is still an important source of protein, the child needs a whole egg or some meat at least once a day. An older child may have both more frequently. Liver has taken an important place among meats because it is very rich in several vitamins and contains also a large amount of iron.

CEREALS, BREAD, AND POTATOES

Cereals, bread, and potatoes are important energy foods because of the large amount of starch they contain. They differ, however, in vitamin and mineral content. Therefore, if potatoes are not included in at least one meal of the day, it is desirable to increase the amount of fresh vegetables or fruit used.

Cereal products differ in minerals and vitamins according to the portion of the grain used in their preparation. The germ portion of the cereal grains contains the vitamin that seems especially valuable in stimulating the appetite of the growing child. It is because of their vitamin and mineral content that entire-grain cereals and whole-wheat bread are recommended for growing children. However, both the kind and amount of cereals and breadstuffs the child should eat depends upon how much potato he takes and upon the variety of his diet in general. Every meal may well include some bread. The child who drinks plenty of whole milk, eats a variety of fruits and vegetables, and gets entire-grain cereals in some form may have the kind of bread he prefers.

VEGETABLES AND FRUITS

Vegetables and fruits are valuable in supplying minerals and vitamins, and they also add much to the variety of color and flavor in the menu. An adequate vegetable allowance for a child includes at least two servings of vegetables each day in addition to potatoes. Because of their vitamin and mineral content the leafy vegetables, spinach, lettuce, endive, chicory, cabbage, Chinese cabbage, chard, Brussels sprouts, broccoli, collards, kale, water cress, dandelion and mustard greens, lamb's-quarters, onions, and the tops of celery, beets, and turnips should have a prominent place in the diet. Thin green leaves, such as spinach, green lettuce, and beet and turnip tops, are richer in iron and in some of the vitamins than bleached, thick leaves such as onion bulbs and cabbage, but all the so-called leaf vegetables and also tomatoes, green beans, green peas, carrots, asparagus, and cauliflower are excellent supplements in food value to tubers and white root vegetables and to cereals and the legumes.

Raw and quickly cooked vegetables are important for good nutrition, since long cooking at high temperature partially destroys the vitamin content of most vegetables. Tomatoes retain their vitamin content when heated, and canned tomatoes are therefore especially valuable when fresh vegetables are scarce. When the season permits, the child's daily diet should include one raw and one quickly cooked fresh vegetable other than potatoes. Leafy green vegetables should be served often when available and tomatoes frequently the year around.

Finely chopped cabbage or celery, grated carrots, chopped lettuce or watercress, and peeled tomatoes may be given raw to most young children. The raw, chopped vegetable, mixed with creamed butter, may be made into small sandwiches for at least one meal a day.

A wide variety of fruits, both raw and cooked, are good for children. Beginning during infancy, the juice or the scraped or sieved pulp of raw, cooked, or canned fruit should be given. The citrus fruits are especially valuable for vitamins and minerals and should appear frequently in the growing child's diet. Tomatoes, really a fruit, are practically interchangeable with citrus fruits in food value. Many child-nutrition specialists advise tomato juice every day that the child does not have citrus fruit of some kind. Bananas are a good vitamin and mineral food, and, if ripe, they may be given to children often. When the seeds of the banana are black and the skin has begun to darken, the pulp is mealy and can be well chewed. For very young children bananas may be baked or the raw pulp mashed. Apples, peaches, apricots, pears, plums, prunes, cherries, and raisins afford plenty of variety in the child's menus. Two fruits a day, at least one raw if possible, aid good nutrition and simplify the dessert problem throughout childhood.

SWEETS

Sweets are concentrated fuel foods. They add interest to the diet but must be given with discretion to children. After proteins and other building materials have been supplied, a moderate amount of sweets may be used to advantage to contribute flavor and to provide calories in a form quickly used by the body. As a safeguard to the child's appetite and his good nutrition, he should not be allowed to have sweet things or large amounts of sweets on food either between meals or early in the meal. It is important to establish the habit early of serving sweets only as dessert or immediately after a meal, and in limited quantities. In this way sweets may become a very good incentive for the poor eater to clear his plate. Given under supervision, suitable sweets for children include raisins, dates, jelly, jam, preserves, raw, ripe, or cooked fruits, simple candies, cake and cookies not too sweet or too rich in fat, custards, puddings, ice cream, fruit sherbets, and other simple desserts.

FATS

Fats are the most concentrated body fuels, containing more energy than sweets and starches. Butter and cod-liver oil are good sources also of vitamins. For this reason the child needs butter every day, and cod-liver oil at least during the winter. Since all fats add flavor and contribute energy, some others may well be included in moderation in the child's diet.

WATER, BEVERAGES, AND SOUPS

Children need plenty of water and should be encouraged to drink it at a definite time in the morning and afternoon to establish the water-drinking habit. (Fig. 2.)

Every food contains some water. Many beverages and soups are mostly water and contain too little food value to justify the room they take up at meal time in the child's small stomach. This is not true of milk, milk soups, cocoa, and fruit juices, which contain more nourishing materials. However, all liquids are filling and should not be allowed to crowd solid foods out of the diet. Tea and coffee, because they are stimulating and are not nutritious, are unsuitable for children.

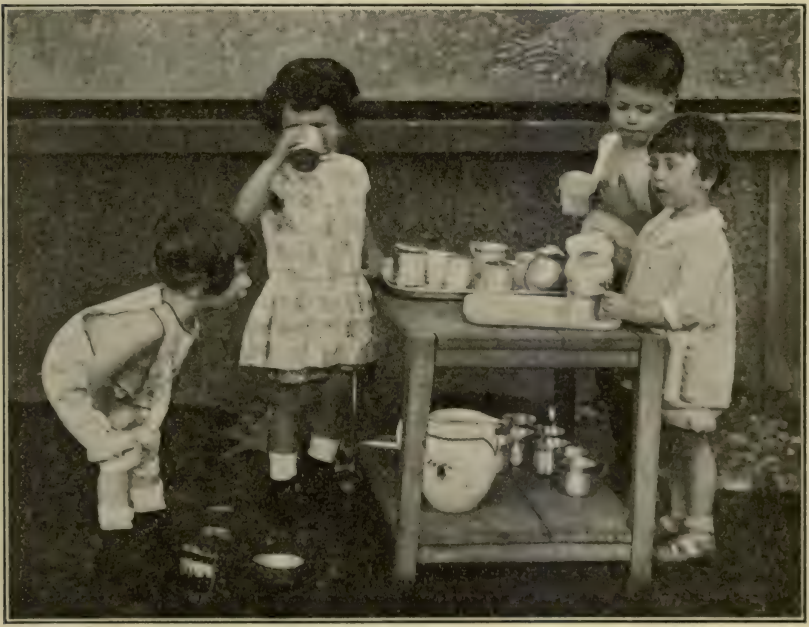

FIGURE 2.—Forming the water-drinking habit at nursery school

PLANNING THE CHILD'S MEALS

THE VERY YOUNG CHILD

There is one period of childhood that causes special concern to many mothers. It lies between the beginning of the weaning period and the age of about 18 or 20 months, while the milk diet is being gradually changed to the mixed and more solid diet of the family group. At first the baby has fruit juices, cereal gruels, fruit and vegetable purees, and soft-cooked egg, with little meat, sugar, and fat, and no coarse material. To remove the coarse particles from cereals, fruits, and vegetables, these foods are put through a sieve. It is not possible to make a definite statement as to how long beyond the weaning period this sieving is necessary, because children differ in their ability to digest coarse food. Solid foods ought to be introduced gradually, getting away from an entirely liquid or semisolid diet as early as possible. Infant Care and The Child from One to Six, two bulletins published by the United States Department of Labor, give more detailed suggestions for feeding during this transition period.

THE OLDER CHILD

As soon as the child has passed the sieved-food stage and has become adjusted to a coarser and more solid diet, his food habits are much the same as an adult's. A well-balanced diet supplies him with the essential building and regulating materials and with enough fuel foods to furnish energy for his constant activity. (Fig. 3.) It is not necessary to meet all these needs in one meal, but they ought to be met in the course of the day or at least in the meals of two or three days. A wisely selected variety for the child includes plenty of milk, some eggs or meat, many fruits and vegetables (citrus fruits, tomatoes, and green vegetables often), cereals and things made from cereals, some fats, especially butter, and a limited quantity of simple sweets.

VARIETY

Early childhood is the best time to introduce a variety of food flavors. There are no food prejudices at birth. Food likes are largely a matter of habit, built up through happy and repeated experiences in tasting. Therefore, strange foods are introduced tactfully, one at a time, and small portions are served until the flavor becomes familiar. Varying the child's early food experiences in this way teaches him the taste of many foods, and develops his willingness to try new things as they are offered.[2]

Variety is obtained not only by using different foods from time to time, but also by preparing and serving them in different ways and by offering them in different combinations. Preparation and combination influence flavor, color, texture, and consistency of the diet quite as much as selection itself, and these four qualities play an important part in making food appetizing and suitable for the child.

Pleasure in meals is often the result of having a favorite food or a combination of flavors that go well together. If a child develops a special fondness for a food because of its flavor, he may have it, of course, but not to the exclusion of other foods. It may be served sometimes along with a food he desires less, as an incentive for him to finish both happily. A mildly flavored dish is enjoyed most when served with one that has more pronounced flavor. Strong-flavored vegetables are better with eggs than with meat, while mild vegetables combine better in a meal with meat.

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[2] Leaflet 42, Good Food Habits for Children.

Colors, too, play their part. Separate foods or certain combinations often appeal so much in color that they influence the desire to eat. There are combinations suitable in food value and in flavor that are not pleasing in color. For example, tomatoes and beets in the same menu appeal less in color than spinach and beets. Since children notice colors, there is an opportunity to teach them to appreciate attractive color combinations in their meals.

FIGURE 3.—Variety that includes building, regulating, and energy materials

CONSISTENCY

The consistency or texture of a food and the form in which it is served may contribute to the variety or monotony of a child's diet. These qualities may also influence a child's ability to feed himself, determine his like or dislike of a food, and play an important part in his tooth development. Texture and consistency are due first of all to the structure of the food itself, though the method of cooking and the size and shape of the pieces prepared for serving may change original characteristics decidedly. For this reason variety can be obtained quite as much through the method of preparing as through the choice of foods.

Vegetables, fruits, and cereals, as well as eggs and meats, lend themselves to so much variety in cooking and in serving that it is unfortunate to make meals monotonous by overworking one type of dish. A very good example of a bad practice of this kind is serving white sauce over every vegetable offered to children, and often combining it also with meat, fish, and hard-cooked eggs. If used occasionally, white sauce adds to the variety of the menu; used too often, it makes every food taste and look the same.

Consistency plays a large part in palatability and also in the ease with which a child can feed himself. To be palatable, rice, potatoes, and mashed vegetables should not be pasty. Creamed dishes should be neither thick and sticky nor too soupy to eat with a fork. Vegetables must not be cut in pieces so small that they are hard for little hands to manage with a fork, nor so large that they are clumsy to eat. Slices or oblong pieces are more easily handled than cubes. The skins of baked fruits and vegetables should either be removed or cut up in small sections easy for the child to eat. Meat or any other food requiring a knife should be divided in small pieces on the young child's plate.

All hard foods such as bread crust and toast, and also meat that has not been ground or scraped, encourage chewing and are valuable for exercising the gums and teeth. Foods of this kind should be given very early in life, but not too often or in such large amounts that eating becomes slow and laborious. Contrast of consistency in the same meal, serving some hard, crisp, or dry foods and some that are soft, makes meals interesting and appetizing.

SIMPLE PREPARATION

Simply prepared dishes in which the natural flavor of the food is retained make the most wholesome and attractive meals for children and for adults as well. This does not mean that food should be bland and tasteless in order to be suitable for children. On the contrary, it should be attractive and tasty, since early childhood is the best time to develop an appreciation for pleasing food flavors and good standards of preparation. In homes where the grown-ups have a well balanced diet, not too rich in fat or too highly seasoned, little if any difference is made in preparing for the children. The mother who chooses dishes suitable for the whole family greatly lightens her work of meal planning and food preparation. (Figs. 4, 5, and 6.) Menus and recipes to make this possible are given farther on.

If adults insist on richer, more highly seasoned food than the children should have, it is still not necessary to prepare two different sets of food. In such cases, high seasonings, extra fat, or more sugar may be added after portions have been taken out for the children. Modifications of this kind can be easily made in many meat dishes, in meat and vegetable stews, and in vegetable and dessert cookery. Such a simple practice as giving the children vegetables without rich sauces, or fruit when the dessert is not suitable for them, is often the only kind of adjustment of the family menu necessary.

SIZE OF SERVINGS

The size of servings should be determined by the appetite and the needs of the child. Nothing is more discouraging to a little child than too large a serving; nothing is more embarrassing to the adolescent boy than to be chided about the amount he eats.

The capacity of the young child is about one-half or one-third as great as the adult's. Therefore his servings should be small. The amount can easily be modified from experience. In presenting an unfamiliar food, it is best to start with only a teaspoonful and increase the portion gradually. A serving of two tablespoonfuls of a familiar, well-liked food is plenty at one time. The child may have more if he wants it when he has cleared his plate.

REGULAR SCHEDULE FOR MEALS

A regular schedule of three meals a day with the food requirement divided fairly evenly seems to work best for most children. If one meal is slightly larger, it is usually given at midday. Because many children sleep more soundly when the evening meal does not include the heavier foods, any food that seems to interfere with sound sleep should not be given for supper. In following this plan, some mothers make the mistake of giving the younger children too light a meal in the evening. This may make the day's food allowance too small and may even cause the child to awaken early the next morning because he is hungry. It is better to omit any foods that seem to cause restlessness and to give large enough servings of the others to make the last meal of the day adequate.

"Piecing" between meals is a bad practice because it is likely to dull the appetite for regular meals. If extra food is necessary for a very active, rapidly growing child, it must be given at a definite time not too near a regular meal hour. It should be of good quality, and the amount and kind should be chosen to supplement properly the diet for the day. The additional food may consist of orange juice or some other fresh fruit such as an apple or a peach, a small sandwich or a cookie, and a glass of milk. If the appetite is at all spoiled for the next meal, the extra lunches should be discontinued.

MENUS

BREAKFAST

Breakfast for the young child usually consists of fruit, cereal, toast with butter, and milk. Serving different cereals and fruits, and varying the way the fruit is prepared makes variety possible. Apples may be baked, stewed, made into sauce, or served raw if the pulp is scraped. Ripe bananas, either baked or raw, are good for children. The juice of an orange is refreshing for breakfast and easy for children to take, but orange sections and slices are equally good. Stewed prunes, apricots, or apples are somewhat changed in flavor by adding sliced lemon or oranges during the cooking. Prunes and apricots may be cooked together for a change or fruit flavor.

A strip or two of bacon cooked until crisp and drained of fat may be served occasionally for variety. There is no objection to egg for the child's breakfast now and then on days when he is not having egg for dinner or supper.

BREAKFAST SUGGESTIONS

Fruit, raw or cooked. (Oranges, grapefruit, stewed prunes, stewed apricots, apples, ripe bananas, peaches, or other fruits in season except seedy berries.)
Cereal with top milk. (Cooked cereals and those containing the germ portion are best.)
Egg or crisp bacon occasionally.
Toast with butter.
Milk to drink.

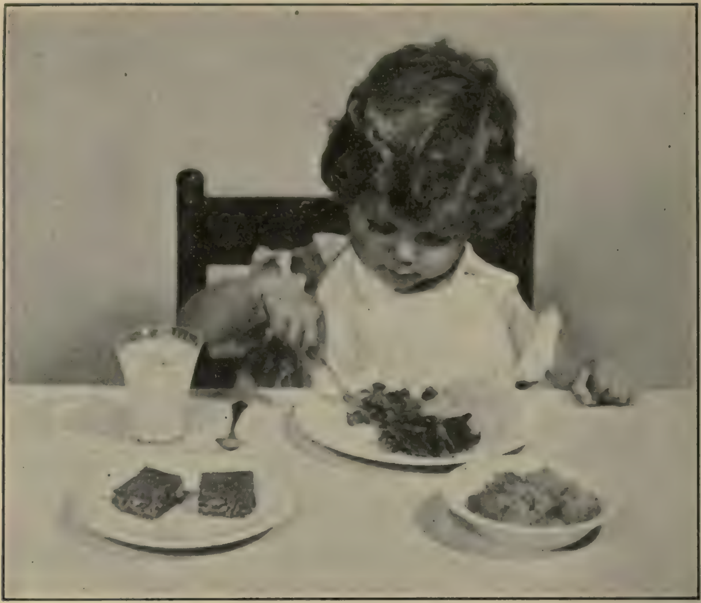

FIGURE 4.—Small servings of the family dinner for the 2-year-old

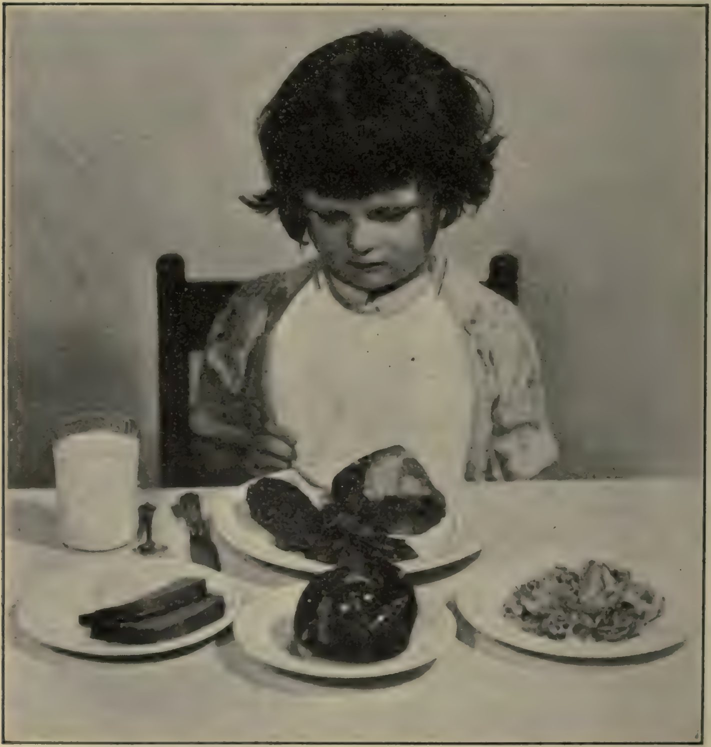

FIGURE 5.—Moderate-sized servings of the family dinner for the 6-year old

DINNER

The slogan for every busy mother should be " One Menu for All." Even dinner, the main meal of the family, can easily be adjusted to the needs of the children if the menu consists of wholesome food simply prepared.

The illustrations (figs. 4, 5, and 6) show children of three ages enjoying the family dinner: Broiled meat ball, buttered string beans, baked potato, bread and butter, lettuce, milk, and baked apple. The size of servings meets the needs of the individual child.

The 2-year old (fig. 4) has small portions. To make eating easy for her, the baked potato and baked apple are removed from the skin and mashed, and the meat ball is divided in small pieces. The midday meal for the young child is usually slightly larger than the other meals. Serving the main protein dish for dinner makes the principal difference between dinner and supper.

The 6-year old's demands are met by moderate portions (fig. 5), while the 10-year old with his hearty appetite and large needs for the building and fuel foods requires very generous servings. (Fig. 6.)

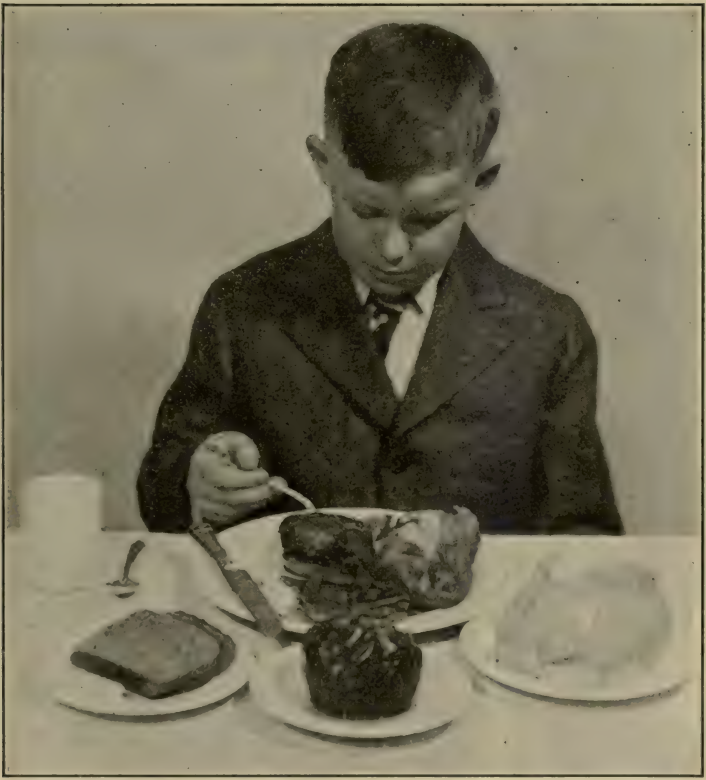

FIGURE 6.—Very generous servings of the family dinner for the 10-year old

The following menus are suitable for children but might well be served to the whole family. Recipes for some of these dishes are found on pages 16 to 21. Other suitable recipes are in Aunt Sammy's Radio Recipes Revised, and in department leaflets on meat, egg, and rice cookery.

These menus are not intended to suggest the preparation of a different dessert for dinner and supper on the same day, for this is of course not practicable or desirable in the busy household. There is no reason why the dessert or any other dish may not be repeated if it is something that keeps well and that will be appetizing when served again.

DINNER MENUS FOR EARLY CHILDHOOD

(Food from the family meal)

Creamed egg.
Buttered asparagus.
Grated carrot sandwich.
Milk.
Raspberry flummery and cookies.

Broiled liver.
Stuffed baked onion.
Scalloped potato.
Water cress sandwich.
Milk.
Sliced orange.

Scrambled eggs.
Creamed cabbage.
Peanut butter and chopped celery sandwich.
Milk.
Chocolate cornstarch pudding.

Broiled lamb chop.
Baked Hubbard squash.
Finely cut cabbage and mayonnaise.
Bread and butter.
Milk.
Baked prune whip.

Meat and vegetable stew.
Buttered new peas.
Toasted rolls.
Milk.
Pear, raw ripe, stewed, or baked.

Baked halibut.
Summer squash.
Sliced ripe tomatoes.
Bread and butter.
Milk.
Tapioca cream.

Omelet.
Creamed mixed vegetables.
Lettuce sandwich.
Milk.
Fruit cup and gingerbread.

Beef broiled on toast.
Stewed tomatoes and celery.
Toast.
Milk.
Creamy rice with apricots.

Casserole of chicken with brown rice.
Scalloped tomatoes.
Panned okra.
Bread and butter.
Milk.
Ice cream.

Liver and rice loaf.
Carrots in parsley butter.
Apple salad.
Bread and butter.
Milk.
Quick blueberry pudding.

Lamb roast.
Baked potato.
Buttered peas and carrots.
Chopped lettuce and parsley sandwich.
Milk.
Sliced peaches, fresh or canned.

Rib roast of beef.
Mashed potatoes.
Swiss chard or other greens.
Bread and butter.
Milk.
Baked apple.

SUPPER

Supper for even the young child includes vegetables and fruits to make sure that his mineral and vitamin allowance for the day is covered. (Fig. 7.) The former cereal-and-milk supper for this period lacked flavor and variety. Also with it there was difficulty in providing adequately the vitamin and mineral needs and getting the child to eat enough food to last him until breakfast time. To prevent early awakening from hunger, the child must eat an adequate amount of substantial food for his supper.

SUPPER MENUS FOR EARLY CHILDHOOD

(Food from the family meal)

Baked potato and bacon.
Fresh tomato and lettuce.
Bread and butter.
Milk.
Muskmelon.

Diced potato with parsley sauce.
Baked beets.
Bread and butter.
Milk.
Lemon sponge with custard sauce.

Sieved Lima beans with bacon.
Baked tomato.
Bread and butter.
Milk.
Apple brown betty or apple sauce.

Milk vegetable soup.
Scalloped cabbage and apples.
Buttered toast.
Milk.
Raisin cup cake.

Creamed spinach on toast.
Cottage cheese on lettuce leaf.
Bread and butter.
Milk.
Fresh strawberries and sponge cake.

Spaghetti with tomato sauce.
Celery hearts.
Bread and butter.
Milk.
Pineapple custard.

Potato puff.
Buttered string beans.
Bread and butter.
Milk.
Sliced ripe banana.

Brown rice.
Buttered kale.
Milk.
Stewed dried apricots.
Oatmeal cookie.

Scalloped egg plant.
Prune and cottage cheese salad.
Bread and butter.
Milk.
Broiled peaches, fresh or canned.

Creamed fish with vegetables.
Buttered toast.
Milk.
Peach or apple tapioca.

Cream of potato soup.
Toasted rolls.
Celery and cooked beet salad.
Milk.
Baked custard.

Poached egg on toast.
Creamed cauliflower.
Toast.
Milk.
Fruit gelatin.

RECIPES

The recipes in the following pages have been chosen because they are suitable for children. Since all these dishes may be served to the whole family, the amounts suggested are sufficient for five or six persons. Many other recipes suitable for children are found in Aunt Sammy's Radio Recipes Revised and in department leaflets on meat, egg, and rice cookery.

EGGS

Young children are usually given poached, soft-cooked, or coddled eggs, but there is no reason why they should not have eggs prepared in other ways. Children enjoy eggs scrambled, hard cooked and served with white sauce, or made into omelets, and such dishes are good for them. Eggs or mixtures containing a good deal of egg must be cooked slowly at a low temperature so that they will be tender when done. Recipes for preparing a number of egg dishes are found in Leaflet 39, Eggs at Any Meal.

MEAT, POULTRY, AND FISH

The small amount of meat given to young children should be tender and easy to chew. Tender cuts may be chosen, or the less tender cuts prepared to make them so. Tender cuts are broiled or oven roasted without moisture; the less tender ones need slow cooking at a low temperature with moisture.[3] Grinding meat in a food chopper or cutting it in small pieces, as in preparing stew and scalloped dishes, makes meat easy for children to eat.

Liver, which should be given occasionally on account of its particular nutritive value, needs special care in its preparation. After the connective tissue is removed, liver should be cooked at a very moderate temperature to prevent toughening. To make it easy for young children to chew liver thoroughly, it should be cut very fine for them, either after it is cooked or before, as in preparing scalloped liver or loaf.

Children are fond of combinations of rice or vegetables and meat, and of creamed or scalloped meat, chicken, or fish. These are very good methods of using left-overs, and of providing children with the small amount of protein they need in addition to that of milk and egg.

BEEF STEW WITH VEGETABLES

1½ pounds beef, rump or round.
¼ cup flour.
2 onions, chopped.
1 quart water.
3 cups diced potatoes.
2 cups diced carrots.
Salt.
2 tablespoons chopped parsley.

Wipe the meat and cut it in inch cubes. Try out the fat in a skillet and add the meat, which has been rolled in the flour, and the chopped onion. Cook and stir until browned. Then transfer the meat and onions to a kettle. Add the water, after first pouring it into the skillet so as to get full benefit of the browned-meat flavor.

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[3] Leaflet 17, Cooking Beef According to the Cut, and Leaflet 28, Lamb as You Like It.

Cover and simmer about one hour. Add the vegetables, and cook until they are tender. Season with salt and sprinkle the top with the parsley after the stew is placed in the serving dish.

LIVER AND RICE LOAF

½ cup rice.
4 cups boiling water.
1 pound sliced liver.
2 tablespoons butter or other fat.
1 small onion, chopped fine.
1 cup chopped celery.
¼ cup chopped parsley.
2 tablespoons flour.
1 cup tomatoes, canned or fresh.
2 teaspoons salt.

Cook the rice in boiling water until tender. Do not drain, but let the rice absorb the water so as to form a sticky mass which will act as a binder for the loaf. Wipe the liver with a damp cloth and remove the skin. Sprinkle the liver with salt and flour and cook in the fat in a skillet for about three minutes. Remove the liver and grind or chop it very fine. Cook the onion, celery, and parsley in the drippings for a few minutes, add the flour and tomatoes, and stir briskly until thickened. Then mix all the ingredients until thoroughly blended, form into a loaf with the hands on parchment paper, place on a rack in an open roasting pan. Bake for about 30 minutes in a moderate oven (350° F.).

CREAMED FISH WITH VEGETABLES

1 pound fish—cod, halibut, or salmon.
1 quart milk.
2 cups diced potatoes.
1 cup diced carrots.
1 finely chopped onion.
4 tablespoons butter.
¾ cup flour.
2½ teaspoons salt.
1 tablespoon chopped parsley.

Simmer the fish in a small quantity of water about five minutes. Drain and remove the skin and bones and flake the fish. Cook the potatoes and carrots until tender and drain. Mix the flour with a small quantity of cold milk, and stir into the heated milk to which the onion, salt, and butter have been added. Cook until thickened. Add the vegetables and the fish, cook for a few minutes longer, sprinkle a little parsley over the top, and serve. If canned fish is used, it does not need the preliminary cooking.

VEGETABLES AND FRUITS

A number of vegetables and fruits may be served raw, with all of their natural flavor and food value retained. They are sometimes cooked to increase their palatability or digestibility for children and sometimes simply to add variety to the diet. In any method of preparation care should be taken to conserve as much of the food value as possible. The tendency in the past was to overcook vegetables. Long cooking at a high temperature destroys some of the valuable vitamins. Some methods of cooking extract the natural juices which contain minerals that must not be drained away. For these reasons fruits and vegetables should be cooked only long enough to make them tender, in the smallest amount of moisture desirable, and the cooking liquid should be saved and served. Mild-flavored vegetables can be steamed or baked without added moisture, or cooked in a small amount of milk or water which is served with them. Strongly flavored vegetables are often more palatable if cooked in a large amount of water to dilute their flavor, but such surplus cooking liquid can be used in soups or sauces. White or cream sauce for vegetables is made from a combination of milk and the vegetable juices extracted in cooking or drained from the can or jar.

Baking, casserole cooking, and scalloping are good methods because they retain all of the nutritive value and flavor of the food. Vegetables and fruits that have a heavy skin to hold in the steam lend themselves especially well to baking. Sweet potatoes, potatoes, tomatoes, winter squash, eggplant, onions, apples, pears, and bananas are examples. Only simple seasonings are needed, such as a little butter and salt for the vegetables, or a little sugar for the fruit if it is tart, though other materials are sometimes added to vary the flavor.

When the structure of the fruit or vegetable makes baking in the skin unsuitable, the casserole or baking dish with some moisture added is a good substitute. Turnips, celery, cauliflower, and cabbage are frequently scalloped. For variety such vegetables as potatoes, onions, and eggplant that can be baked whole are pared, cut up, and scalloped.

The flavor and texture of some vegetables and fruits make pleasing combinations when cooked together. For instance, apples may be scalloped with carrots, cabbage, or sweet potatoes. Other good combinations are stewed tomatoes and okra, tomatoes and finely cut celery, carrots and peas, celery and peas, and carrots and turnips. Some of these vegetables are especially good creamed, either alone or together. A recipe for creaming four vegetables as one dish is given below. It may be adapted to other vegetable combinations, and offers an attractive way of using small amounts of several kinds of vegetables.

Vegetable, egg, and milk combinations make an excellent main dish for the child. Corn pudding and carrot custard are familiar basic recipes that can be varied by using fresh asparagus, diced turnips, or any other vegetable that has enough flavor to give the dish character.

STEWED TOMATOES AND CELERY OR CABBAGE

1 quart canned tomatoes.
2 cups cut celery or cabbage.
1½ teaspoons salt.
2 tablespoons butter or other fat.

Simmer the tomatoes and the celery together for 20 minutes, or until the celery is tender. Season with salt and fat and serve. This is an excellent way to use the other stalks of celery that are less desirable for serving raw. Or, after the tomatoes have cooked alone for about 15 minutes, add finely shredded cabbage instead of the celery. Cook the tomatoes and cabbage together for from 5 to 10 minutes, add the seasoning, and serve at once.

SCALLOPED CABBAGE AND APPLES

2 quarts shredded cabbage.
1 quart tart sliced apples.
2 teaspoons salt.
2 to 4 tablespoons butter or other fat.
1 teaspoon sugar.
1 cup buttered bread crumbs.

Place alternate layers of the cabbage and apples in a greased baking dish. Season each with salt and fat and sprinkle the sugar over the apples. Spread the buttered crumbs over the last layer. Cover, and bake in a moderate oven for 45 minutes, or until the cabbage and apples are tender. Remove the cover toward the last of the baking so that the crumbs can brown. Serve from the dish.

CREAMED CABBAGE

3 cups milk.
1½ quarts finely shredded or chopped cabbage, packed.
4 tablespoons flour.
4 tablespoons melted butter.
1 teaspoon salt.

Heat the milk and cook the cabbage in it for five minutes. Add the blended flour and butter and the salt. Cook for about five minutes longer and stir constantly. The cabbage retains its delicate flavor and color.

STUFFED ONIONS

5 large mild onions.
3 tablespoons butter or other fat.
1½ cup chopped celery.
2 tablespoons chopped parsley.
2 cups bread crumbs.
1 teaspoon salt.

Skin the onions, cut in half crosswise, simmer in salted water until almost tender, and drain. Remove the centers without disturbing the outer layers and chop fine. Melt two tablespoons of the fat in a skillet, add the chopped onion, celery, and parsley, and cook for a few minutes. Push the vegetables to one side, melt the remaining fat and add to it the bread crumbs and salt, and then combine with the vegetables. Fill the onion shells with the stuffing, put in a baking dish, cover, and bake in a moderate oven

FIGURE 7.—Supper includes vegetables and fruits even for the very young child

for about 30 minutes, or until the onions are tender. Remove the cover from the baking dish during the last of the cooking so that the onions will brown on top.

CREAMED MIXED VEGETABLES

1 cup diced potatoes.
1½ cups diced carrots.
1 cup diced turnips.
2 cups finely chopped cabbage.
2 tablespoons melted butter.
2 tablespoons flour.
1½ teaspoons salt.
1 cup milk.

Cook the potatoes, carrots, and turnips in three cups of boiling water until almost tender. Add the cabbage, allowing about five minutes for cooking. Prepare a sauce of the melted butter, flour, salt, and milk. Cook until thickened and stir this sauce into the vegetables. Cook a few minutes longer, until the desired consistency is reached, and then serve.

CARROT OR TURNIP CUSTARD

3 eggs.
1½ cups grated raw carrot or turnip.
3 cups milk.
1 teaspoon salt.
3 tablespoons melted butter or other fat.

Beat the eggs slightly, add the carrot and other ingredients, pour into a greased baking dish, place on a rack in a pan of hot water, and bake in a moderate oven for about one hour, or until the custard is set in the center. Serve at once.

BAKED BEETS

3 bunches, or 6 cups diced beets.
2 tablespoons water.
2 tablespoons sugar.
2 tablespoons butter.
1 teaspoon salt.

Wash, pare, and dice the beets. Place them in a casserole, add the water, sugar, butter, and salt. Cover and put the casserole in a moderate oven for one and a half to two hours. Stir the beets occasionally while cooking, and when tender serve from the dish.

DESSERTS

Raw, stewed, or baked fruits served alone, in fruit-cup mixtures, or stewed-fruit combinations, offer many possibilities for children's desserts. Fruit mixed with cereal and served with top milk or thin cream makes a good dessert. Puddings made of rice, tapioca, or bread are often flavored with fruit. Cornstarch, rice, and bread puddings flavored with a little chocolate, cocoa, or caramel are popular with children. Cereal puddings of this kind, custards, milk sherbets, and simple ice creams provide good means of including milk in the diet if there is difficulty in getting children to drink it. Eggs, sometimes not welcome alone, may be worked into such desserts as tapioca cream, prune whip, rice and bread puddings, floating island, and a number of gelatin desserts. Any milk and eggs used in preparing the child's food should be counted as a part of his day's allowance.

BAKED PEARS

Wash the pears, cut in half, core, and place in a baking dish. Sprinkle with sugar and a little salt, dot with butter, add a very little water, cover, and bake in a moderate oven. As soon as the fruit becomes soft, remove the cover so that the sirup will cook down. Serve hot or cold, with or without cream.

CREAMY RICE WITH APRICOTS

½ cup rice.
1 cup boiling water.
1½ cups milk.
½ teaspoon salt.
½ cup sugar.
2 cups chopped fresh fruit or dried fruit soaked and cooked.

Cook the rice over direct heat in the cup of boiling water. When the water has been almost absorbed put the rice in a double boiler, add the milk, salt, and sugar. Cover and cook until the rice is tender. Mix the rice and fruit and when chilled serve with top milk or cream. Canned grated pineapple gives an excellent flavor.

BREAD PUDDING

1 quart milk.
2 cups dry bread crumbs.
½ cup sugar.
¼ teaspoon salt.
2 tablespoons butter.
1 cup seedless raisins.
1 teaspoon vanilla.
3 eggs.

Scald the milk, bread crumbs, sugar, salt, and butter in a double boiler. Pour some of the hot mixture into the beaten eggs, reserving two whites for the meringue. Combine all the other ingredients, pour into a greased baking disk, and set in a pan of hot water. Bake in a moderate oven (350° F.) for about one hour, or until the pudding is firm in the center. When the pudding has partly set, stir well so the raisins will be scattered through the pudding rather than at the bottom of the dish. To make the meringue add two tablespoons of sugar to each well-beaten egg-white, and add a dash of salt and vanilla. Cover the pudding with the meringue and put in a very moderate oven (about 325°) for 15 to 20 minutes, or until lightly browned. Serve hot or cold, garnished with bits of tart red jelly.

APPLE BROWN BETTY

2 quarts pared and cored diced tart apples.
1 quart bread crumbs (oven toasted until crisp and light brown).
1¼ cups sugar.
1 teaspoon cinnamon.
¼ teaspoon salt.
¼ cup melted butter or other fat.

Grease a good-sized baking dish and place in it a layer of crumbs, then a layer of apples, and some of the sugar, cinnamon, and salt, which have been mixed together. Repeat until all the ingredients are used, saving sufficient crumbs for the top. Pour the melted butter or other fat over the top layer of crumbs, cover, and bake in a moderately hot oven for 45 minutes, or until the apples are soft. Toward the last remove the cover and allow the top to brown. Serve hot with cream or top milk.

RASPBERRY FLUMMERY

2 cups of raspberry juice from canned or cooked fresh raspberries.
½ cup sugar (if juice is unsweetened.)
3 tablespoons cornstarch.
¼ teaspoon salt.
1 or 2 tablespoons lemon juice.

Heat the raspberry juice in a double boiler, add the sugar, cornstarch, and salt, which have been thoroughly mixed, stir until the mixture thickens, cover, and cook for 15 to 20 minutes. Remove from the stove, add the lemon juice, beat well, pour into a serving dish, and chill. Serve with cream or top milk.

POINTERS FOR PARENTS

Remember that the food the child eats makes a difference in his growth and development and his fitness for life. (Fig. 8.)

Be sure that his diet includes all the materials necessary for good bones, sound teeth, and other needs.

Start when he is an infant to teach him to like a wide variety of wholesome foods.

Stimulate his appetite by good health habits.

Serve him carefully planned, well-prepared meals at regular hours.

Watch his development closely and have periodic medical examination so that if he is not growing normally or keeping healthy, medical attention may be given in time.

FIGURE 8.—Happy, healthy, well nourished

U. S. GOVERNMENT PRINTING OFFICE: 1931

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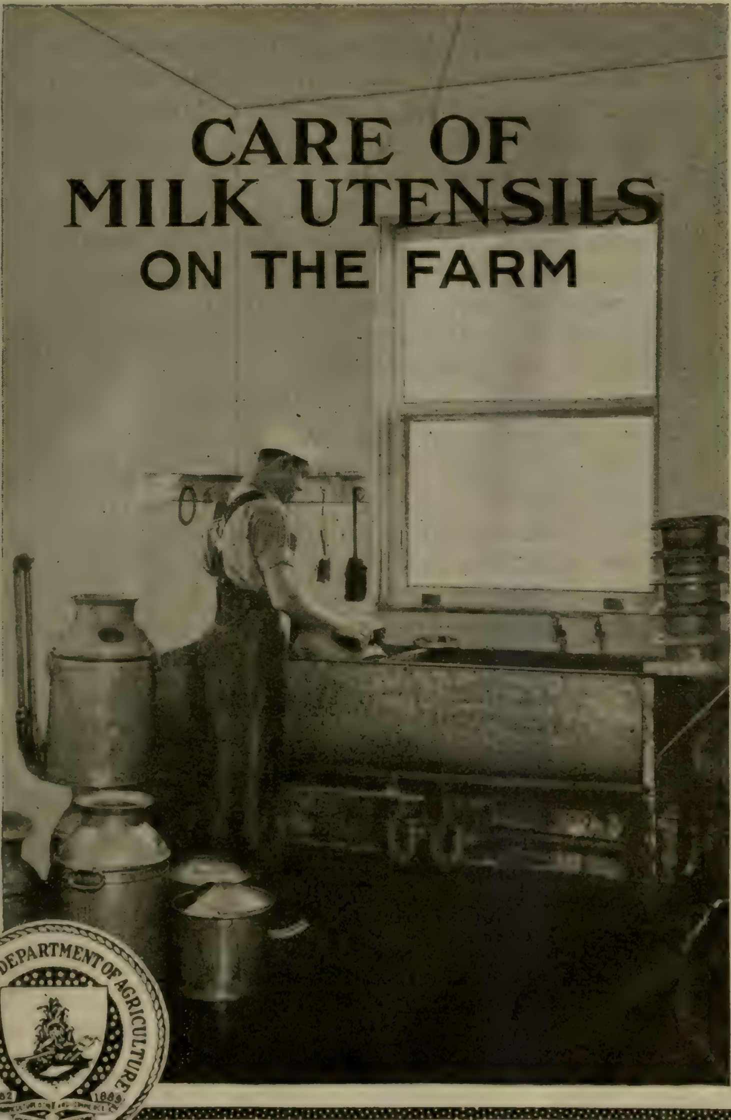
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1675

CARE OF MILK UTENSILS ON THE FARM



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ALL UTENSILS with which milk comes in contact should be carefully washed and then treated to kill bacteria before being used.

All utensils, before being treated to kill bacteria, should be washed with hot water and an alkali or soda-ash washing powder, and then be rinsed in clean, pure water. Brushes, not rags, should be used.

In dairies that have steam boilers, utensils can be steamed effectively in a properly constructed cabinet, preferably with perforated coils on the floor to distribute the steam evenly.

For dairies that do not have steam boilers, a galvanized-iron box steamer and water heater in which steam is generated by a fire underneath will serve satisfactorily. Steaming cabinets of this type are easy to operate and may be made at relatively low cost by any good tinsmith.

A steam jet may be used for treating such utensils as cans and pails, but to kill the bacteria the utensils must be steamed until they are too hot to be handled with bare hands.

Where public-health authorities permit their use, chlorine solutions carrying 200 parts of available chlorine to 1,000,000 parts of water can be used to treat dairy utensils to kill bacteria. Utensils should be thoroughly drained so that none of the chlorine solution will get into the milk.

Blue prints of different types of steam cabinets may be obtained free from the Bureau of Dairy Industry, United States Department of Agriculture, Washington, D. C.

This bulletin is a revision of, and supersedes, rmers' Bulletin 1473, Washing and Sterilizing n Milk Utensils.

Washington, D. C. Issued September, 1931

CARE OF MILK UTENSILS ON THE FARM

By R. J. Posson,[1] *Associate Market-Milk Specialist*, and Ralph P. Hotis, *Associate Market-Milk Specialist, Division of Market-Milk Investigations, Bureau of Dairy Industry*

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FAILURE TO CLEAN MILK UTENSILS thoroughly and properly treat [2] them to kill bacteria is one of the main reasons why milk and cream sour. The matter of the cleanliness of the utensils can not be overemphasized, as the retail fluid-milk market requires high-quality milk and cream. The manufacturers of high-grade dairy products of all kinds also insist on quality in the milk and cream. High-quality dairy products can not be made from low-quality milk and cream.

The tiny bacteria that cause souring, off flavors, and sometimes sickness, grow and multiply very fast on the moist surfaces of untreated or improperly treated pails, cans, strainers, etc. Although the utensils may appear to have been washed well, they are not really clean unless most of the bacteria have been killed. Even in grandmother's day the clean dairy, with its spotless, shining utensils, which had been thoroughly scalded, was noted for its good butter. And to-day the dairies with clean utensils, thoroughly treated to kill bacteria, usually lead in the production of high-quality milk and cream which are low in bacteria.

The quantity and kind of equipment required for washing and treating dairy utensils depend upon the size of the dairy. Small dairies usually need only simple equipment, but in the larger dairies the use of more elaborate equipment is generally more economical.

THE WATER SUPPLY

For washing and rinsing utensils, a clean, safe water supply is absolutely necessary. Contaminated water may be a source of danger to health, not only to those on the farm but to all those who use milk from the farm. Wells and springs should always be protected from surface drainage. The drainage from privies, hogpens, barnyards, and other sources of contamination should always be away from the well, and both springs and wells should be walled in, curbed, and kept tightly covered.

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[1] Mr. Posson resigned from the Bureau of Dairy Industry on Jan. 23, 1928.

[2] The expression "treat to kill bacteria" is used instead of "sterilize," because sterilize means to kill all the bacteria, whereas the process commonly used with dairy utensils kills a large proportion of the bacteria but not necessarily all of them.

HOW TO WASH UTENSILS

Milk utensils should always be throughly washed and rinsed before being placed in the steaming cabinet or treated with chemical solution. Improperly washed utensils are not only more difficult to treat to kill bacteria, but any milk which may be adhering to the utensils may form a deposit. This residue furnishes food for any bacteria which may remain alive after steaming or chemical treatment, enabling them to multiply and contaminate the fresh milk, and makes the utensils harder to clean the next time that they are washed.

The same principles apply to washing utensils in dairies of all sizes. Always remove with cold or lukewarm water as much as possible of the foreign material, milk, and cream adhering to the surfaces of the cans, pails, bottles, and other utensils. Otherwise the wash water soon becomes dirty, highly contaminated with bacteria, and unfit for use. By first rinsing the utensils, washing is made easier and more effective, and less washing powder is required to clean them. After the utensils have been rinsed, remove all remaining foreign matter by scrubbing with a brush, hot water, and an alkali or soda-ash washing powder.

The wash water should be about as hot as the hands will bear. The amount of washing powder required will vary with the hardness of the water and the kind of powder. Enough should be used to "break" the water, so that grease may be removed from utensils. Soap or greasy powder should not be used for washing milk utensils. Before the washed utensils are treated to kill bacteria they should again be rinsed in clean, pure water, either hot or at least slightly warm.

The illustration on the cover page shows the washing room of a farm milk house.

EQUIPMENT FOR WASHING UTENSILS

In all farm dairies where washing is done by hand, the equipment required for washing utensils is the same in type and simple in construction. In dairies where there are few utensils to wash, smaller wash sinks of lighter construction than in the large dairies may be used, and less expensive equipment for heating water will be required, but in general the needs are much the same.

A galvanized-iron round-bottom sink or vat is a decided help in washing utensils. Such a sink may be bought from dairy supply houses. It should have two compartments—one for washing and one for rinsing. By connecting it with a drain and piping water to it, labor is saved and the work of washing is made much easier. (Fig. 1.)

Brushes of various shapes and sizes for different purposes save time and enable one to thoroughly clean the utensils. Rags should not be used, because they are difficult to free of bacteria and have a tendency to smear grease and other foreign matter instead of loosening it as a brush does.

A separate room, preferably adjoining the one in which the milk is handled, should be provided for washing the utensils. If there are only two rooms in the milk house it is preferable to wash the utensils in the room in which the boiler or stove is situated rather than in the room where the milk is handled. The floor of the wash room should be water-tight and should slope toward a drain.

STEAMING UTENSILS

The utensils may be effectively treated to kill bacteria by placing them in a tight cabinet and turning steam from the boiler into the cabinet for a long enough time to accomplish the result desired. If the boiler is of sufficient capacity, the inside temperature of the cabinet and the utensils may be raised in a few minutes to about that of boiling water. If the steam is evenly distributed in the cabinet, and a reliable thermometer in the top of the cabinet shows that a temperature of 200° F. or higher has been maintained for five minutes or longer, it is certain that the number of bacteria on the utensils will be greatly reduced; a period of time slightly longer than five minutes gives a margin of safety.

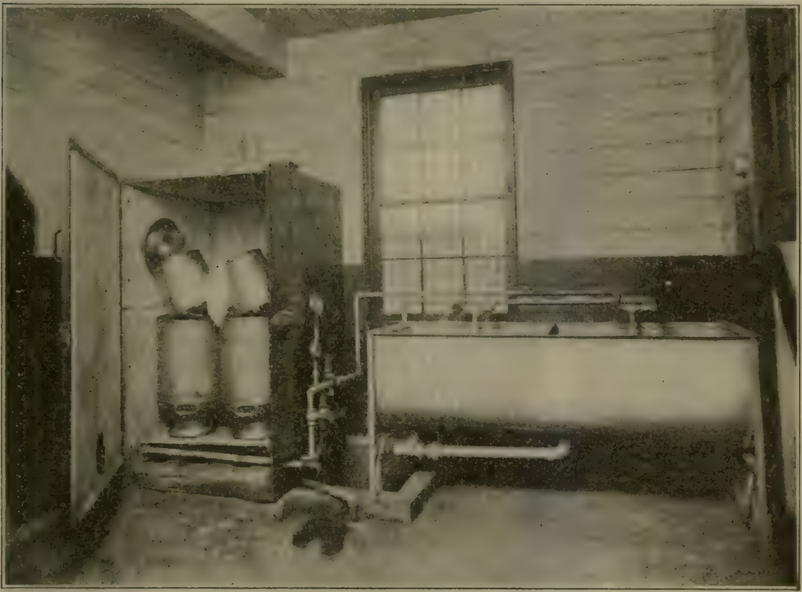

FIGURE 1.—A wooden steaming cabinet, lined with galvanized sheet iron; and a galvanized-iron wash sink, with washing and rinsing compartments

Utensils such as cans, pails, and bottles should always be placed in the cabinet in an inverted position. If they are placed open end up it will take longer to heat the utensils, and the condensed steam can not drain from them. Large steaming cabinets may be equipped with slatted shelves or racks, preferably constructed of galvanized angle iron or piping, upon which the utensils may be placed. This saves space and aids the circulation of the steam. Bottles may be treated in their cases, but, if it is desirable to save space, they may be satisfactorily handled on removable shelves or racks having holes in them to receive the necks.

As steam has a tendency to rise, it should be liberated underneath the utensils, and, if possible, at the bottom of the cabinet. Also it should enter the cabinet from several openings, in order that it will be evenly distributed. One way which has proved satisfactory is to admit the steam through a perforated pipe coil laid on the floor of the cabinet. Another way is to construct shelves of piping connected with the boiler, the center pipe in each shelf being perforated about every foot. The utensils are inverted on these shelves. Coils similar to the ones shown in Figure 2 may be placed on the floor of the cabinet. It will be noted in this instance that the steam passes through a long closed coil before it reaches the perforated coil. This closed coil may be used as a radiator to furnish heat for drying the utensils by closing the valve that admits steam to the perforated coil.

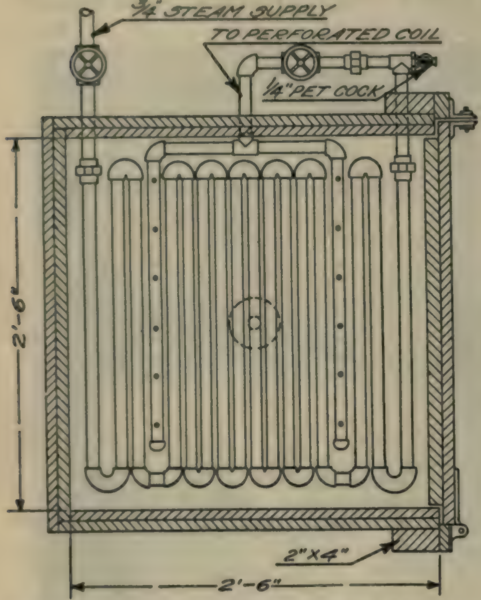

FIGURE 2.—Perforated and closed coils which may be used on the floor of the steaming cabinet to distribute the steam in the cabinet and then dry the utensils after they have been steamed.

CONSTRUCTION OF STEAMING CABINETS

Steaming cabinets may be made of various materials. Wood, galvanized iron, reinforced concrete, hollow tile, brick, or stone, or any material which is not easily damaged by steam and of which a tight box can be constructed, may be used. In the case of wood it is better to use two thicknesses of boards, put on at different angles to prevent warping. A wooden cabinet of one thickness of boards, with a water-tight lining of galvanized iron, makes a satisfactory cabinet. The door should fit tightly so as to prevent the escape of steam.

Wooden cabinets constructed of two thicknesses of 1-inch lumber and galvanized-iron cabinets are practically equal in efficiency. They are about two and one-half times as efficient in the use of steam as uninsulated concrete cabinets. At least twice as much time, and more than twice as much steam, are required to heat an uninsulated concrete cabinet as are required for either of the other cabinets. A steam boiler which is taxed to capacity in operating a concrete cabinet with uninsulated walls 4 or 5 inches thick will furnish enough steam for a wooden or galvanized-iron cabinet more than twice as large: therefore, a boiler of only half as much capacity will be needed to operate a wooden or galvanized-iron cabinet as would be required for a cabinet made of uninsulated concrete.

It is advisable to equip the cabinet with a safety valve set to open at a low pressure. The ordinary cabinet will withstand very little steam pressure. Increase in pressure gives somewhat higher temperature, but the advantage of the higher temperature from using Steam at high gauge pressures is more than offset by the leakage of steam. Utensils can be made practically free from bacteria by steaming with low pressure.

There should be a drain in the floor of the cabinet to carry off condensed moisture. The drain should be water sealed, which may be done by installing a U trap in the drainpipe. The lower part of the trap will remain full of water, which prevents the escape of steam through the drain. If drying coils are to be used after the utensils are steamed, there should be a damper near the bottom of the cabinet and one in the top. The upper damper should open into a galvanized pipe which is extended to carry the vapor outside the building. The cabinet should have a small hole in which to place a thermometer. The most protected place for this is usually in the top of the cabinet or the upper part of the door.

OPERATION OF STEAMING CABINETS

The operation of a steaming cabinet is a simple matter. The time required to reach a sufficiently high temperature in the cabinet for killing most of the bacteria depends upon several factors, including the size and construction of the cabinet, the capacity of the boiler, the pressure of steam developed, the number and size of utensils, and the temperature of the surrounding air. After the temperature of the cabinet has been 200° F. or above for five minutes, the valve leading to the perforated coil may be closed. It may be found in practice that the temperature inside the cabinet will remain high for several minutes after the steam is turned off.

If glass bottles are being treated, steam should be turned in slowly at first, to prevent breakage. For the same reason the cabinet should not be opened or the bottles moved until the temperature has fallen.

Unless utensils are dried in the cabinet or are to be used within a few hours, they should be removed from the cabinet as soon as they are cool enough to handle and inverted on a rack to drain and dry, in a clean place protected from all contamination. Drying after steaming prolongs the life of the utensils, by preventing rust, and it also retards later bacterial growth. It is important to dry utensils thoroughly soon after steaming if they are not to be used within 24 hours.

Drying coils in the cabinet will be found to be a distinct advantage in drying the utensils. When drying coils are in use, the dampers in the bottom of the door and in the top of the cabinet should be opened to permit escape of the moisture evaporated from the utensils after they have been steamed. To dry the utensils, the valve leading to the perforated coil should be shut, and the valve between the closed coil and the boiler left open. The petcock on the closed coil (fig. 2) should be opened slightly so as to let the water from the condensed steam escape. When the cabinet is hot enough to dry the utensils, the steam-supply valve should be closed and the petcock opened wide. A thermostatic trap may be installed in place of the petcock; this will automatically allow the water from the condensed steam to escape.

THE GALVANIZED-IRON BOX STEAMER

In small dairies where the milk is bottled, and in some wholesale dairies which do not have steam boilers, utensils may be treated to kill bacteria efficiently and economically in a galvanized-iron box. This box is simple in construction, easy and economical to operate, and may be made by almost any tinsmith at small cost. The box is equipped with a tightly fitting lid, and may be set on a concrete, brick, or stone foundation which serves as a fire box, or on a gas or oil stove, or some other heating device. One-half to three-quarters of an inch of water is used in the box.

The utensils are placed in this container on a slatted rack 1 or 2 inches off the bottom to keep them above the water. The lid is then put on and enough heat applied underneath the box to boil the water. The steam generated soon raises the temperature in the box to about that of boiling water. A thermometer should be inserted in the lid in order to show when this temperature is reached. This temperature should be maintained at least five minutes. The process is exactly the same as for any other steaming cabinet, except that the steam is generated within the box.

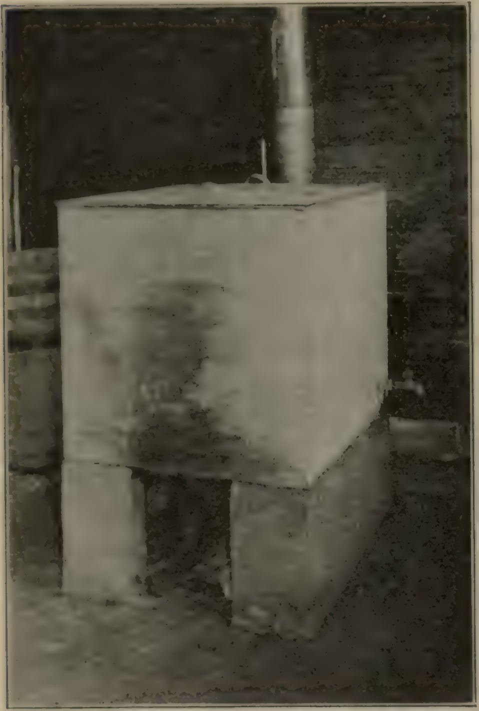

FIGURE 3.—Galvanized-iron box for heating water and treating utensils in small retail and medium-sized wholesale dairies. A steam boiler is not required

In experiments made by the bureau, the bacteria contained in 10-gallon cans after they had been washed and rinsed were practically all killed by steaming the cans in the box shown in Figure 3. Each of these cans contained, on the average, at least 80,000,000 bacteria before being treated, as compared with 2,100 after the treating.

This box may also be used to heat the water for washing the utensils. If steaming immediately follows washing, only a comparatively small quantity of fuel is needed for steaming if most of the water has been drawn off for washing. Enough water should be left so that the box will not be dry upon completion of the steaming process.

Blue prints of this box and instructions for operating it, and also blue prints of steaming cabinets for use with steam boilers, may be obtained free from the Bureau of Dairy Industry, United States Department of Agriculture, Washington, D. C.

USE OF A STEAM JET

Utensils such as cans and pails may be treated to kill bacteria by inverting them over a steam jet, but this system is not recommended because there is no way of knowing the temperatures reached and thus making sure that the heat applied has been sufficient to kill bacteria. More care must be taken in drying the utensils, and there is more temptation for the operator to slight his work, than in the case of the other three methods described.

The effectiveness of the jet depends upon the steam pressure used (as shown by the steam gauge), the size of the opening through which the steam is ejected, and the length of time the utensils are steamed. It usually requires about half a minute to steam a 10-gallon can thoroughly if the steam pressure is 20 to 25 pounds. If a steam jet is used, the utensils should be steamed until they are too hot to handle with the bare hands. After treatment in this manner they will become dry from their own heat if placed right side up and left uncovered for a few minutes before they are inverted on the rack.

Steam jets may be made easily by extending a pipe from the boiler half an inch or an inch up through the drain board of the sink and providing a valve in the pipe directly beneath the drain board by which the steam may be turned on and off.

KILLING BACTERIA ON LARGE EQUIPMENT

Utensils and equipment, such as coolers and bottle fillers, which it may not be practicable to put into the cabinet, may be treated by covering tightly and turning in steam or boiling water. If running water is available, it may be heated with steam by means of a mixing tee and run over the cooler or into the bottler and other equipment, at about boiling temperature. The boiling water comes in direct contact with the surface of the utensils, kills bacteria, and also rinses the utensils. This method is preferable to that of attempting to free utensils from bacteria by shooting steam at them through a hose. Steam applied through a hose has lost much of its heat by the time it reaches the bacteria and so serves only as a meager rinse. When water is used, care should be taken that it is boiling hot and that enough is used to heat the utensils thoroughly. A satisfactory way to treat bottlers is to fill them full of boiling water and allow them to stand five minutes or longer. Milking-machine rubbers and teat cups also may be treated with hot water, although slightly different treatment is required than for other utensils. Directions for cleaning milking machines are given in Farmers' Bulletin 1315, Cleaning Milking Machines, a copy of which may be obtained free by writing the Office of Information, Department of Agriculture, Washington, D. C., as long as there is a supply available for free distribution.

CHEMICAL TREATMENT OF UTENSILS

Another method of treating utensils to kill bacteria is by the use of chemicals. A number of chemical compounds will kill bacteria, but not all of them are suitable for use with dairy utensils. The chemicals commonly used for treating dairy utensils are sodium hypochlorite, calcium hypochlorite, and compounds containing chloramines. Before using this method it should be ascertained whether the board of health recognizes and permits its use.

MAKING CALCIUM HYPOCHLORITE SOLUTIONS

In using calcium hypochlorite, prepare a stock solution by making a smooth watery paste of 12 ounces of commercial chloride of lime containing 30 per cent available chlorine (or 15 ounces of chloride of lime containing 24 per cent available chlorine), and then adding water slowly and stirring thoroughly until the solution amounts to 2 gallons. Let this settle and then strain into a tightly closed glass bottle or jar and keep it in a cool, dark room. Add 1 pint of this stock solution to every 8 gallons of water for the final rinse. Use this immediately. The used rinse solution should be thrown away and a fresh rinse dilution made up just before the next treatment of the utensils. It is advisable not to make larger quantities of stock solution than can be used within two weeks time.

MAKING SODIUM HYPOCHLORITE SOLUTIONS

Make a smooth watery paste of 12 ounces of commercial chloride of lime containing 30 per cent available chlorine (or 15 ounces of chloride of lime containing 24 per cent available chlorine), then add water slowly and stir thoroughly until the solution amounts to 1 gallon.

Dissolve 27 ounces of washing soda (use the common crystals, not powder or cooking soda) in 1 gallon of warm water. If chloride of lime containing 24 per cent available chlorine is used, it will require 34 ounces of washing soda.

Mix these two solutions, stir thoroughly, and let stand for several hours. Strain or siphon off the clear liquid into a tightly closed glass bottle or jar and keep it in a cool, dark room.

One pint of this stock solution should be added to every 8 gallons of water for the final rinse.

These rinse solutions contain about 200 parts of available chlorine to 1,000,000 parts of water, which is the strength recommended for farm use.

Chlorine compounds in various forms and under numerous trade names are on the market. They usually cost more than the home-made solution, but some labor is saved in that a stock solution need not be prepared and they are usually more uniform in strength.

Farm dairy utensils may be treated with chlorine solutions in two ways: By immersing, and by spraying. By immersing the utensils in a tank containing the chlorine solution the entire surface comes in contact with the chemical. Each utensil should be completely immersed and left for at least two minutes. The spray method may be used for large utensils and is especially suitable for treating coolers in which both water and brine flow. The sprayer used should be of the pressure type, capable of covering considerable area with a fine spray.

It is essential that every particle of organic matter be removed before treatment with chlorine compounds, as milk, cream, or other organic matter weakens the effect of the chlorine solution on bacteria. The solution should be applied immediately after completion of the washing process. Turn the utensils upside down in a clean, dry place free from odors and all sources of contamination, and do not touch until needed.

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